COMPARATIVE EVALUATION OF POSITIONAL ACCURACY OF IMPLANTS WITH TWO DIFFERENT SPLINTING MATERIALS USING TWO DIFFERENT ELASTOMERIC IMPRESSION MATERIALS - AN INVITRO STUDY.

Dissertation submitted to

THE TAMILNADU Dr. M.G.R. MEDICAL UNIVERSITY

In partial fulfillment for the degree of

MASTER OF DENTAL SURGERY

BRANCH – I

PROSTHODONTICS AND CROWN AND BRIDGE

MAY -2019

THE TAMILNADU Dr. M.G.R. MEDICAL UNIVERSITY

CHENNAI – 600032

2016 – 2019

CERTIFICATE - I

This is to certify that the dissertation titled **"COMPARATIVE EVALUATION OF POSITIONAL ACCURACY OF IMPLANTS WITH TWO DIFFERENT SPLINTING MATERIALS USING TWO DIFFERENT ELASTOMERIC IMPRESSION MATERIALS - AN INVITRO STUDY. "** is a bonafide work done by **Dr. A.KAYATHRI**, Postgraduate student, during the course of the study for the degree of "Master of Dental Surgery" in Department of **PROSTHODONTICS AND CROWN & BRIDGE**, CSI College of Dental Sciences and Research, Madurai during the period of 2016-2019, under our supervision and guidance.

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ETHICAL COMMITTEE

Title of the work : Comparative evaluation of positional accuracy of implants with two different splinting materials using two different elastomeric impression materials: An in-vitro study

Principal investigator: Dr.A. Kayathri (PG Student) **CSICDSR/IEC/27-1D/2016**

Department: Department of Prosthodontics

The request for an approval from the Institutional Ethical Committee (IEC) for the above mentioned study, submitted by the Principal investigator is considered in the IEC meeting held on 08.09.2016 at CSI College of Dental Sciences and Research, Madurai. The members of the committee are unanimously pleased to approve the proposed work mentioned above and is '**Advised to proceed with the study'**

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DECLARATION BY THE CANDITATE

TITLE OF DISSERTATION	COMPARATIVE EVALUATION OF POSITIONAL ACCURACY OF IMPLANTS WITH TWO DIFFERENT SPLINTING MATERIALS USING TWO DIFFERENT ELASTOMERIC IMPRESSION MATERIALS - AN INVITRO STUDY.
PLACE OF STUDY	CSI COLLEGE OF DENTAL SCIENCES AND RESEARCH, MADURAI
DURATION OF COURSE	3 YEARS
NAME OF THE GUIDE	Dr. B.SIVA SARANYA MDS.,
HEAD OF THE DEPARTMENT	Dr.R.LAMBODHARAN MDS.,

I hereby declare that no part of the dissertation will be utilized for gaining financial assistance for research or other promotions without obtaining prior permission of the Principal, CSI College of Dental Science and Research, Madurai. In addition, I declare that no part of this work will be published either in print or electronic without the prior permission guide who has been actively involved in dissertation. The author has the right to reserve the publication of work solely with prior permission of the Principal, CSI College Dental Sciences and Research, Madurai.

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CERTIFICATE – II

PLAGIARISM CERTIFICATE

This is to certify that this dissertation work titled **"COMPARATIVE EVALUATION OF POSITIONAL ACCURACY OF IMPLANTS WITH TWO DIFFERENT SPLINTING MATERIALS USING TWO DIFFERENT ELASTOMERIC IMPRESSION MATERIALS - AN INVITRO STUDY"** of the candidate **Dr. A.KAYATHRI** for the award of **MASTER OF DENTAL SURGERY** in the **BRANCH I – PROSTHODONTICS AND CROWN AND BRIDGE.**

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ACKNOWLEDGEMENT

I express my sincerest and at most thanks to ***Dr.R.LAMBODHARAN., MDS,*** *Professor & Head, Department of Prosthodontics, CSI College of Dental Science and Research, Madurai. He is an inspiration to all and has provided me full support, encouragement and motivation for completion of this dissertation.*

My heartful thanks to ***Dr. B.SIVA SARANYA**, **MDS,*** *Reader, Department of Prosthodontics, CSI College of Dental Sciences and Research, Madurai, who has guided me with constant support whenever necessary. Her guidance and mentorship has been the navigation for my dissertation, without whose help the completion of this dissertation wouldn't have been possible.*

I am deeply grateful to ***Dr.K.THANVIR MOHAMED NIAZI, MDS*** *Principal, C.S.I College of Dental Sciences and Research for his kind permission, encouragement and for providing me with all the facilities needed to complete this work.*

*It gives me great pleasure to thank the staff members,**Dr.K.Babu Rajan MDS, Dr.P.Jesu Doss MDS, Dr.S.Sabarinathan MDS, Dr.S.Deenadayalan MDS, Dr.R.MuthuKumar MDS, Dr.C.Divagar MDS,** Department of Prosthodontics, C.S.I College of Dental Sciences and Research, Madurai, for their valuable insights during my study.*

*I am indebted to all my **Family members**. My love and gratitude for them can hardly be expressed in words. I take this opportunity to thank them for supporting me throughout my journey.*

I would like to take this opportunity to thank my ***co pgs Dr.J.DhivyaPriya, Dr.Vaishnavi.V.S*** *who provided me with the much needed support and constant motivation over the course of the study.*

I take this opportunity to express my thanks to the ***Non-Teaching Staffs*** *of the department, who have helped me directly or indirectly in the making of this dissertation.*

I thank the ***LORD ALMIGHTY*** *for providing me this opportunity and granting me the capability to proceed successfully.*

CONTENTS

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DHAYA CALIBRATION
Engineering Instrument

No.78, 1st Floor, TPK Road,
PR Complex, Andalpuram,
Madurai -625003

Mobile No: 9842143016, Off: 04524378016
Email: nallasivamdaya@gmail.com
Web site: www.dhayacalibration.com

CERTIFICATE OF CALIBRATION

Certificate No	:	DCEI/2194/2017
Name of the Customer	:	**Miss.Dr.A.KAYATHRI,** CSI COLLEGE OF DENTAL SCIENCES AND RESEARCH No.129, East veli Street, Madurai-625001

Details of Instrument:

Description	:	TORQUE WRENCH
Make	:	ALPHA BIO
Range	:	0 -40 NCM
Identification Number	:	TW - 01
Date of Calibration	:	23.11.2017
Next Calibration	:	22.11.2018

Reference Equipment Traceability:

The above instrument is calibrated with our Master pressure gauge which is traceable to National standards by, NPL, Delhi, Ministry of Micro Small & Medium Enterprises Testing Center **(Govt of India)** Chennai. Certificate No- **MSME 5440/ 2016-2017**, Date of calibration: **28.02.2017,** Next Due on: **28.02.2018**

Environmental Condition: Temperature: 25° ± 2°C Relative Humidity: 40 - 70 % Result of calibration: Refer page 2

Remarks

Test reading given was the average of 3 measurements.

CALIBRATED BY

M.Muthu

M.MUTHU SANTHOSH

DHAYA CALIBRATION ENGINEERING INSTRUMENTS MADURAI
CALIBRATION

APPROVED BY

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CALIBRATION CERTIFICATE

CERTIFICATE NO : DCEI/2194/2017 DATE: 23.11.2017

CALIBRATION RESULTS

SL NO	STANDARED READING	MEASURE READING	OBSERVED ERROR
1	0.00 NCM	0.00 NCM	0.00 NCM
2	10.00	10.00	0.00
3	20.00	20.00	0.00
4	30.00	30.00	0.00
5	40.00	40.00	0.00

VISUAL INSPECTION : OK WORKING CONDITION:OK

CALIBRATED BY

The reported results are valid only the condition of the received above instrument/gauge at the time of under the stated condition of the calibration

For **Dhaya Calibration Engg Instruments**

DHAYA CALIBRATION ENGINEERING INSTRUMENTS
CALIBRATION DONE
MADURAI-11

ANNEXURE II

LIST OF FIGURES

Figure No: **Title**

ANNEXURE III

LIST OF GRAPHS

Graph No: Title

Introduction

INTRODUCTION

Osseointegrated implants have provided better result than conventional complete denture prosthesis for the edentulous patients[38]. The use of dental implant is one of the fixed treatment option given to the patient. The endosseous implants have showed the higher survival rates and long term success rate. The diagnosis and treatment planning, gentle surgical procedure, accurate impression making, passive fit of prosthesis, development of proper occlusion scheme and recall maintenance are the important factor for the success rate of implant. The failure of implant may be due to improper surgical procedure, inaccurate prosthodontic procedure, lack of passive fit of prosthesis, presence of occlusal discrepancies[17].

One of the important factor for long term implant success is dependent upon the accurate design of prosthesis which should have an impeccable, passive fit to the implant. This prevents mechanical and biological failures in implant treatment. The biomechanical problems like screw loosening, fatigue, fracture of implant components, peri- implantitis, bone loss and later disintegration occur due to lack of passive fit of the frame work[9]. This is the matter of greater concern especially in multiple implant conditions such as partially edentulous and fully edentulous situations.

Various clinical studies have been reported that range of 10μm to 15μm is acceptable level of discrepancy of the framework[25]. The precise transfer of the spatial relationships of implants from mouth to the master cast with an accurate impression procedure is the first and critical step for designing the passive fit of implant framework[29]. The accurate inter implant relationship in working cast is obtained by the accurate impression techniques. Recent lab procedures like CAD/CAM with digital impression technique, soldering procedure, laser welding are some of the procedure that are followed to fabricate an impeccable passive prosthesis.

The ultimate goal of passively fitting implant prosthesis is an important factor in implant dentistry is achieved using accurate transfer of implant position to working cast. The various factors influence the accuracy of impression are impression technique, different connection level (implant level and abutment level), different impression trays, impression material, implant depth, time delay for stone pouring[30].

The splinting of impression copings is necessary for accurate implant impression in multiple implant situations. There various types of impression techniques include direct and indirect impression technique and impression material, available for implant impression making[9,48].

Indirect impression technique (closed tray) involves the use of tapered impression copings which do not get picked up in the impression. It needs the repositioning of impressions with analogs attached back to the impression. The advantages of this technique is that the implant replicas are visually fastened to the impression copings and therefore ensuring its complete seating. The disadvantages of this technique is reseating of the copings in the impression may not be accurate, which indicate the error in the inter implant relationship in a vertical axis[41,58].

Direct impression technique (open tray) uses impression copings that are picked up in the impression and analogs are connected to the copings. The advantage of this technique is coping remains in the impression and analogs are attached to coping. This reduces the error during cast pouring[55]. Among the direct impression technique, the splinted impression technique was more accurate than the non-splinted impression technique [18,37].

Splinting of open tray impression copings has been suggested by many authors in order to maintain a more accurate inter implant relationship, when compared to that obtained with non-splinted copings. Although splinting with pattern resin, impression plaster, silicones and bite registration polyether have been used as splinting material in several studies[15,39,29].Rigid splinting of impression coping with pattern resin have been advocated to achieve accurate open tray impression by various authors[19].

Recently a newer material, Bis GMA was used to splint the impression copings, because of its advantages such as easy handling, less time consuming, less technique sensitive which is readily available[46].

Impression materials such as vinyl polysiloxane (VPS) and polyether (PE) impression materials are commonly used to produce final impression in fixed and implant prosthodontics. VPS and PE exhibit excellent dimensional stability under different test and storage condition. PE produced satisfactory dimensional stability under dry and moist condition. PE produced better surface details than VPS under moist conditions. In 2009, vinyl polyether silicone impression material was commercially introduced. This impression material is composed of VPS and PE and is promoted as a hydrophilic material. Various studies proven the dimensional stability of this material. Studies comparing the dimensional stability of VPES and PE materials showed similar results and also VPES behaves more like PE. Hence VPES material was used in this study[34].

Several methods have been advocated in the literature for comparing the accuracy of impressions includes strain gauge method and measuring method. Measurement of the distances between the implant replicas in the master model and comparing them with that of the experimental model have been reported in the previous studies. Devices like travelling microscope, digital micrometer, measuring microscope, optical scanner, profile projector have been used for this purpose [9,28,14,26,27,48,49,39]. It is necessary to study the inter implant distances in x, y and z axis and also the angular measurements in z-axis in order to study the linear and rotational distortion of the impression copings and implant replicas. Coordinate measuring machine (CMM) is an appropriate device to measure the inter implant distances and angulations in the three axes. A Coordinate measuring machine is a device which measures the distance of the analogs from a reference point in the three different axes (x, y and z axes) and also calculate the amount of rotational distortion, linear rotation, as well as measure the inter implant angulation[29,43].

Many studies evaluated the positional accuracy of implants with different impression materials, and have reported higher positional accuracy with VPS impression material. Also comparative studies on the positional accuracy of implants with different splinting materials and have reported pattern resin showed more accuracy[47].Various impression materials and splinting techniques are advocated in several studies but accuracy in impressions are still lacking.

In light of the above considerations, the aim of this study was conducted to compare and evaluate the positional accuracy of implants with two different splinting materials with two different elastomeric impression materials.

1. To evaluate the positional accuracy of implant using pattern resin splinting material and impression making with Vinyl poly siloxane.
2. To evaluate the positional accuracy of implant using Bis GMA splinting material and impression making with Vinyl poly siloxane .
3. To evaluate the positional accuracy of implant using pattern resin splinting material and impression making with Vinyl poly ether silioxane.
4. To evaluate the positional accuracy of implant using Bis GMA splinting material and impression making with Vinyl poly ether silioxane.
5. To compare the positional accuracy of implant using pattern resin splinting material and impression making with Vinyl poly siloxane and Vinyl poly ether silioxane.
6. To compare the positional accuracy of implant using Bis GMA splinting material and impression making with Vinyl poly siloxane and Vinyl poly ether silioxane.
7. To analyse the comparative evaluation of the positional accuracy of implant impression using pattern resin and Bis GMA splinting material and impression making with Vinyl poly siloxane and Vinyl poly ether silioxane.

Review of Literature

REVIEW OF LITERATURE

W.B.Eamest et al (1979)[12] There are five steps involves in achieving accurately fitting casting are impression material, die, wax pattern, investment and casting procedure. The impression materials are chosen according to their accuracy, dimensional stability, working time, shelf life, electroplating capabilities and taste.

Mark R.Spector et al (1990)[44] The passively fitting prosthesis is important for fabrication of superstructure which is fitted into osseointegrated implants. The failure in passive fit lead to loss of fixture integration, progressive treatment failure. The micro fractures of a bone caused due to forced tightening of the superstructure.

Robert M.Humphries et al (1990)[21] Oral rehabilitation success is dependent on the accurate registration of structure that supports the prosthesis. The impression must be accurate and then only master cast duplicate the clinical condition. The accuracy of master casts fabricated from three impression techniques commonly used with the Branemark system was measured.

Alan B.Carr et al (1991)[10] A five implant mandibular model was used to produce seven casts by both the indirect and direct transfer coping technique. The dental cast framework fitted to the master cast is compared for accuracy of the technique used. The direct impression techniques with open tray provide better accuracy.

Alan B.Carr et al (1992)[11] The understanding of the accuracy and precision of all phases of fabrication and connection, is required for passively fitting implant superstructures. There was no significant difference was found between the splinted and unsplinted indirect technique on comparing.

Paolo Vigolo et al (1993)[50] The achievement of an accurate passive fit of a prosthesis on osseointegrated implants obviously demands an accurate master cast. An endosseous implant distributes the physiologic load imposed on it into the supporting tissues. The maximum accuracy is achieved by splinting the transfer coping together with any resin materials.

Chi-Chi Hsu et al (1993)[20] An accurate master cast is a prerequisite for the fabrication of a precise dental prosthesis. The accurate transfer impression procedure is important for construction of implant superstructure and it help in avoiding the prosthesis errors.

J.N.Walton (1994)[54] The clinical problems such as unstable occlusion, improper oral hygiene, speech difficulties are caused due to improper fit of prosthesis to the implant. Evaluating the success of an implant-supported prosthesis includes assessing maintenance needs, specifically adjustments and repairs, and patient satisfaction.

David Assif (1996)[3] The misfit of implant supported prosthesis due to the lack of tensile, compressive and bending forces. A primary factor in increasing the precision fitting of prosthesis is dependent on the accurate impression procedure. The direct impression technique shows better accuracy.

Gamal Burawi (1997)[8] Accurate impressions and working casts are essential for conventional prosthodontics procedures on natural abutment. A passive fit of framework to the abutments of the osseointegrated implant supported prosthesis is important for the success of the restoration.

Joseph Y.K.Kan (1999)[25] The successful long term osseointegration is depends upon passive fit of implant framework and underlying structure. The acceptable level of misfit of prosthesis to the implant support prosthesis is 150µm is said by Jemt.

Alving.Wee (2000)[55] The impression made with polyether and addition silicones are not having any significant difference between the accuracy of direct implant impression said by Barret et al.

M.Lorenzoni (2000)[31] The impression material polyether and polyvinylsiloxane is particularly suitable because of their favourable physical characteristics, their stability with regard to dimension.

Jason Burns (2003)[9] The rigid custom trays produced significantly more accurate impression than polycarbonate stock trays. Direct impression copings procedure more accurate impressions. The rigid elastomeric impression material maintains impression accurately and dimensionally stable.

Charles J.Goodcare (2003)[17] The surgical complications, implant loss, bone loss, peri-implant soft tissue complications, mechanical complications, and esthetics/phonetics complication are six major categories of complication have been reported.

Paolo Vigolo (2003)[49] The verification of cast procedure in the framework fabrication process is done by the framework reorientation procedure. The cross wing design that was rotated into contact with an adjacent coping and connected with autopolymerizing acrylic resin.

Paolo Vigolo (2004)[48] The definitive cast was achieved due the splinting of square impression copings joined together by autopolymerizing acrylic resin is improve the accuracy of cast. The implant has 4mm deep internal engagement with thick coronal walls and uses a system of engagement that confirms proper seating of different components.

Eduardo Batista Franco (2007)[14] Vinylpolysiloxane suggested to be more dimensionally stable than polysulfide and condensation silicones. Because of the dimensional stability of vinylpolysiloxane became popular material for dental impression. The stability of material depends on extact moment of pouring stone dies. To avoid the distoration of the impression.

Sina Jannesar (2007)[23] To make implant impression by using modified dual impression technique using the custom tray. This impression technique used to register the residual ridge under the load and anatomic condition using two impression materials.

Assuncao Wiriey Goncalves (2008)[4] The accuracy of impression procedure is one of important factor for success of implant prosthesis. The airborne adhesive-coated on impression coping. To decrease the micro movement of coping inside the impression material from impression making to cast pouring and to increase the accuracy of the cast.

Heeje Lee (2008)[28] There was no effect of implant depth on the dimensional accuracy. During the cast fabrication procedure, the splint technique was more accurate this was due to accuracy of the implant impression over multiple laboratory procedures.

Mary P.Walker (2008)[53] The impression technique affects the accuracy of the cast which may lead to misfit of prosthesis. The indirect impression technique using screw-on metal impression at implant level yield more accuracy than abutment level impression.

Hans-JurgenWenz (2008)[56] The long- term clinical success of the implant restoration depends upon accuracy of impression material used, passive fit of the prosthesis. The dimensional accuracy achieved by non-splinted direct technique or splint indirect technique, impression material used was addition cured silicone result in most accurate cast.

Heeje Lee (2008)[30] The rigidity to hold the impression copings and to prevent accidental displacement. The minimal positional distortion between implant replica are the two requirements for impression material for the direct implant impression technique.

Humberto Gennari Filho (2009)[13] During the transfer impression technique, the square coping was splinted using prefabricate acrylic resin, have decreased the polymerization shrinkage and increase the system stability.

Hariharan Ramasubramanian (2010)[19] In direct technique both splinting and non-splinting have been advocated for accurate impression. Splinting the impression copings helps in rigidity and dimensional stability of such interocclusal recording materials.

Glen H.Johnson (2010)[24] The dual arch tray with VPS produce greater success than full tray with PE. The VPS impression material shows greater impression success during implant level impression procedure. The VPS impression material was most commonly used material.

Sujatha S.Reddy (2011)[45] The VPS impression material have better elasticity and dimensional stable in comparison to polyethers. So VPS is most widely used impression material in restorative and prosthetic dentistry.

Sang-Jik Lee (2011)[29] VPS bite registration material used as splinting material is better than acrylic resin splint and unsplinted group. The impression made with square impression coping.

D.R.Prithiviraj (2011)[38] In order to make the exact position of the implants during the processing of the master cast and which help in passivity of the framework casting to it supporting abutments without interference between the prosthesis connections is achieved by accuracy of impression procedure is one of most important factor for success of implant prosthesis.

D Ongul (2012)[35] Splinting impression copings with acrylic resin provide better result than the non-splinted techniques or splinted using a light curing composite. Clinical situations where impressions of multiple implants in edentulous arches must be made and the pick-up implant impression technique is used.

Preeti Agarwal Katyayan (2012)[26] There two forms of hydrophobic nature of VPS impression material. The first form describes the surface energy of unpolymerized liquid phase of the impression material. The ability to moist the oral tissues during impression making. The second form describe the surface energy of the solid polymerized VPS and the high contact angle that ideally forms when the VPS impression material are moist with dental gypsum material.

Ozcelik Tuncer Buark (2012)[36] In implant supported over denture condition, the implant and soft tissues have different resilience. The functional impression technique used to record the both mucosa and implant components along the alveolar tissues in the same time. The major benefit of this technique is that records implant components and the supporting tissue in accurate manner.

G.Vivekananda Reddy (2012)[51] The nature of impression material to be used is important to achieve an impression with accurate details of oral structure. The contact angle play the important role in determining the nature of the impression material and to make an accurate cast

Oliver Schaefer (2012)[41] The parameters such as impression material, tray selection, rheological properties, impression technique are help to achieve the accuracy. The wetting behaviour, moisture displacement capability, flow under pressure are physiochemical properties have also been investigated as important character for accuracy of impression.

Gracis et al (2012)[18] The factors such as implant connection type, the design of the connection, lack of parallelism between multiple implants, the impression materials and the technique employed has influence the accuracy of implant level impression.

S Reddy (2013)[40] The impression material like polyvinylsiloxane and polyether have similar dimensional accuracy for transfer procedures in parallel and angulated implant. The impression making in parallel and angulated implant polyvinylsiloxane and polyether material are recommended.

Nassar et al (2013)[34] The Exalence impression material has the properties of both VPS and PE and has more dimensional stability property. The cast pouring immediately after impression making is more accurate than delayed pouring of cast.

Kurtulmus-Yilmaz S et al(2014)[27] For parallel implants, more accurate impressions were obtained with splinted direct technique. The VPS shows most accurate impression material and splinted direct technique was most accurate in presence of angulated implant situations.

Sunantha Selvaraj (2014)[46] The splinting material like acrylic resin and Bis GMA is used to splinted the impression copings together during implant level impression in direct technique. On Comparison both the material exhibits same results.

Pujari Malesh (2014)[39] The cast obtained use of square impression coping is more accurate than non-modified impression coping during implant level impression. The square impression coping is commonly used during implant level impression.

Alikhasi et al (2015)[1] The implant impression materials like PVS and PE are most commonly, used impression material because of dimensionally stable due to the polymerization reaction involves no loss by products. The PVS and PE have the good physical and mechanical properties. It has more accurate surface detail reproduction.

Vojdani et al (2015)[52] In clinic practice common finding during implant surgery, lack of implant parallelism and lack of parallelism between implant and tooth. This is caused due to anatomical consideration and esthetics limitation. Implant impression cause distortion because of undesirable path of impression with drawal.

Sreeramulu Basapogu (2016)[6] In 1970 VPS impression material were introduced. The VPS is used implant dentistry because it has low polymerization shrinkage, low creep property, good surface reproduction, dimensional stability, because they do not release by product.

Prakash S (2016)[37] The success of implant therapy depends upon the following factor impression techniques, like transfer and pickup technique, open and closed techniques, splinted or nonsplinted techniques, accuracy of impression depends upon the angulations of implant depth, copings used.

AyseGozde Turk (2016)[5] The VPS and PE impression material were clinically acceptable material of choice in implant level impression. The accuracy of impression material depends upon the composition of impression material, size of filler particles, and fluid mechanics of flow into very small spaces.

Sonam Gupta (2017)[43] The vinylsiloxanether, is the newer generation elastomeric material in combination of both polyvinylsiloxane and ployether material. It has both material properties as one impression material. It is commercially available material. It is used in implant dentistry.

Sama Nassar (2017)[33] The small dimensional changes occur in the addition silicone and polyether at percentage of -0.15 to -0.20 respectively with half of the 24 hour contraction occur within the first hour after setting. The ploymerization due to cross-linking and rearrangement of bonds in polymer chains cause contraction in elastomeric impression material.

Jajira Nausheen (2017)[22] The essential prerequisite for maintaining osseointegration is by passive fitting of prosthesis. There are two type of technique for implant impression like direct and indirect technique. The dimensional accuracy of implant definitive is depends upon the technique used, the open tray and closed tray exhibits no significant difference on comparison.

Materials and Methods

MATERIALS AND METHODS

The aim of the present in-vitro study was conducted to compare and evaluate the positional accuracy of implants with two different splinting materials using two different elastomeric impression materials.

MATERIALS EMPLOYED:

- Modelling Wax No:2 (Hindustan dental products, Hyderabad, India) (**Fig:1)**
- Heat cure acrylic resin (DPI-Heat cure polymer and monomer, Mumbai, India) (**Fig:2)**
- Cold cure acrylic resin (DPI-cold cure polymer and monomer,Mumbai,India) (**Fig:3)**
- Pattern Resin (GC Corporation, Tokyo) (**Fig:4)**
- Protemp^{TM}4 Temporization Material (3M ESPE, Germany) (**Fig:5)**
- EXA'lence VPES Impression Material (GC America) (**Fig:6)**
- EXAMIX^{TM}NDS Impression Material (GC America) **(Fig:7)**
- Honigum-Putty Impression Material (DMG, Germany) (**Fig:8)**
- Tray Adhesive (Coltene, Maharshtra) (**Fig:9)**
- Die Stone (Pearl stone, Asian chemicals, Gujarat) (**Fig:10)**
- Alginate (DPI Algitex, Karnataka) (**Fig:11)**
- Plaster of Paris (White Gold, Asian Chemicals, Gujarat) (**Fig:12)**
- Misseven demo implant standard platform with a dimension of 3.75x11.50mm (**Fig:13)**
- Mis implant analog internal hex (**Fig:14)**
- Mis open tray impression coping (**Fig:15)**
- Custom made mould **(Fig:16)**

INSTRUMENTS AND EQUIPMENTS EMPLOYED:

- Wax Knife and Lecron Carver (GDC,Hoshiarpur, Punjab) (**Fig:17)**
- Laboratory Micromotor (NSK, Japan) (**Fig:18)**
- Classic Rubber Bowl and Straight Spatula (GDC, Hoshiarpur, Punjab) (**Fig:19)**
- Surveyor (Bio art- Delineador, Netherlands) (**Fig:20)**
- Vaccum mixer with vibrator,(Cuumyx, confident ,Bangalore) (**Fig:21)**
- Edentulous mandibular mould (Nissin, Japan) (**Fig:22)**
- Co-ordinate Measuring Machine(Tesa, Chennai) (**Fig:23)**
- Twenty Custom trays (**Fig:24)**
- Torque wrench (Alpha – Bio, Israel) (**Fig:25)**
- Dental flask with clamp (Jabbar, Uttar Pradesh) (**Fig:26)**

DESCRIPTION OF VINYL POLY SILOXANE (Monophase) IMPRESSION MATERIAL (VPS):

VPS is an elastomeric impression material because of its thixotropicity offers exceptional dimensional stability, elastic recovery and tears strength, and “immediate pour” capability. Since it is a hydrophobic material by adding surfactant enhances the material's wetability, reducing contact angles and surface tension so it reaches all areas for precise replication. It also allows stone to flow more evenly into the impression and produce accurate models. VPS has excellent elastic recovery and tear strength for easy removal with no distortion or damage to models. It offers stable impressions that can be used up to two weeks[26].

DESCRIPTION OF VINYL POLY ETHER SILICONE (Heavy body and Light body) IMPRESSION MATERIAL (VPES):

VPES impression material is a blend of a polyether and a vinyl polysiloxane (VPS) material. This provides the hydrophilic (wetting) properties of a polyether along with the higher tear strength of VPS that allows it to perform well in critical area such as in the gingival sulcus. Better hydrophilicity means more precise flow subgingivally with fewer voids and bubbles. Additionally, the better tear strength subgingivally provides more accurate replication of the subgingival anatomy, including the preparation margin, implant level impression[34].

DESCRIPTION OF VINYL POLY SILOXANE (Putty) IMPRESSION MATERIAL:

VPS has excellent thixotropic property, precise detail reproduction and outstanding stability in the tray as well as intraorally. It has remarkable flow properties under light pressure, balanced hydrophilicity, and pleasant odour and has adequate working time. It is used for crown and bridge, inlay/onlay,and full mouth restorations.

DESCRIPTION OF PATTERN RESIN SPLINTING MATERIAL:

Pattern Resin is a self-curing, general purpose acrylic resin used for making patterns for splinting the impression coping during implant impression. Fabrication of copings for FPD, post and core build-ups, lingual and palatal bars, implant attachments, adhesion bridges, clasps, telescopic crowns[16]. Certain pre-soldering techniques also. It sets quickly with minimal shrinkage, allows both direct and indirect pattern making, and leaves no residue after burnout.

DESCRIPTION OF BIS-GMA SPLINTING MATERIAL:

BisGMA temporisation material has set another milestone in temporary crown and bridge materials. BisGMA has been applied its expertise in nanotechnology to create the first bis-acrylic composite with a new generation of sophisticated fillers. The result is unparalleled achievements in strength, handling and aesthetics. Reliably tough temporaries due to its highest fracture resistance, better abrasion stability and also suitable for long-term temporisation. It has the advantage of esthetics and a comfortable fit through a smooth surface, natural shine, fluorescence and has higher colour stability. Easy, fast handling and fabrication due to the reduced smear layer and has good glossy surface.

DESCRIPTION OFCOORDINATE MEASURING MACHINE:

A coordinate measuring machine (CMM) is a device that measures the geometry of physical objects by sensing discrete points on the surface of the object with a probe. Various types of probes are used in CMMs, including mechanical, optical, laser, and white light. Depending on the machine, the probe position may be manually controlled by an operator or it may be computer controlled. CMMs typically specify a probe's position in terms of its displacement from a reference position in a three-dimensional Cartesian coordinate system (i.e., with X, Y, Z axes). In addition to moving the probe along the X, Y, and Z axes, many machines allow the probe angle to be controlled to allow measurement of surfaces that would otherwise be unreachable. It is used to find out the angle formed between the axis of implant to the base of the model and cast respectively to the horizontal.

METHODOLOGY:

I. Reference model fabrication

II. Evaluation of reference model using Coordinate measuring machine

III. Custom made mould

IV. Custom tray fabrication

   a. Preparation of primary cast

   b. Preparation of spaced primary cast

   c. Fabrication of custom tray

   d. Grouping of the Sample

V. Preparation of master casts

VI. Evaluation of master casts using Coordinate measuring machine

VII. Results and statistical evaluation

I. REFERENCE MODEL FABRICATION:

A wax model **(Fig: 27)** of the edentulous mandibular arch was obtained by flowing modelling wax into an edentulous mold. The wax model was then mounted on a dental surveyor **(Fig: 28)** and four implant replicas of 3.75x11.50mm MIS were placed into the edentulous wax model in the mandibular symphyseal region to mimic clinical situation. The analogs were placed in a manner such that the one of the trilobes was facing labially. It was also ensured that the 2mm polished collar remained outside the model to ensure visualisation in coordinate measuring machine. Two stops were cut in the land area of the wax model, 2mm x 2mm, one on either side molar region, to act as stops for the custom tray during impression making. The stops were made to ensure similar orientation of all the custom trays on the reference model. Cover screws were screwed on to the implant replicas and an acrylic reference model was obtained by processing the wax model in heat cure acrylic resin (DPI Heat cure, India) **(Fig: 29)**. The reference model was finished and kept undisturbed for 24 hours.

II. EVALUATION OF REFERENCE MODEL USING COORDINATE MEASURING MACHINE:

The reference model was evaluated using a Coordinate measuring machine (CMM, Tespa calibration centre, Chennai, India) which is capable of measuring in x, y and z axes with an accuracy of ±5μm. The CMM was connected to a data processor which gave the measured values. In order to measure the three dimensional accuracy of the reference model, the inter implant distances in x, y and z axes were measured and the angle between the implant replicas and base of the cast were evaluated. The implant replicas were numbered 1 to 4 starting from the left to the right.

The probe used in the CMM was first calibrated. The reference model was measured to obtain the reference values. The model was screwed in the base for measuring. In order to obtain similar orientation of the reference model and all the master casts, the centre of replicas1and4 were aligned in the CMM and then the measurements were made.

Measurements were made in all the three axes namely x, y and z. The distance between replica 1 and 2 was denoted as D1. The distance between replica 1and 3 was denoted as D2. The distance between replica 1 and 4 was denoted as D3. The angulation in replica1 was denoted as Angle 1. The angulation in replica 2 was denoted as Angle 2. The angulation in replica 3 was denoted as Angle 3. The angulation in replica 4 was denoted as Angle 4

Measuring distance in x axis:

The coordinates of the centre of replica 1 was measured and zeroed. Keeping this position as a reference, the positions of the centre of replica 1 and 2(D_1X), 1 and 3(D_2X), and 1 and 4(D_3X) were measured in the X plane x-axis.

Measuring distance in y axis:

The coordinates of the centre of replica 1 was measured and zeroed. Keeping this position as a reference, the positions of the centre of replica 1 and 2(D_1Y), 1 and 3(D_2Y), and 1 and 4(D_3Y) were measured in Y plane Y-axis.

Measuring distance in z axis:

Then the probe was used to measure the plane formed by the platform of replica 1. The open tray impression copings were connected to the implant replicas and screwed at 15Ncm torque[46]. The plane formed by the flat surfaces of each impression coping were measured. The distance between the planes formed by the replica platforms were measured. The distance between the plane formed by the replica platform number 1 and 2 (D_1Z), 1 and 3 (D_2Z) and 1 and 4 (D_3Z) were measured to get the inter implant distance in the z axis.

Measuring angulations in z axis:

In order to find the angular relationship between the replicas, the open tray impression copings were connected to the implant replicas and screwed at 15Ncm torque. The plane formed by the flat surfaces of each impression coping were measured. The angle formed between the implant replicas 1 (Angle1), 2 (Angle 2), 3 (Angle 3), 4 (Angle 4) were measured by calculating the angle formed by the flat surfaces of the respective impression copings. Each measurement on the reference model in all the three axes were measured 5 times and the mean measurements were obtained. All the measurements were made by a single operator to avoid inter operator error.

III. CUSTOM MADE MOULD:(Fig: 16)

The custom made mould was made up of stainless steel. It had upper and lower plates. Lower plate consists of four compartments with dimensions of 25mm x 2mm x 2mm. It has two screws on top of upper plate. The screw head was made up of plastic. The pattern resin was placed in all compartments and closed with upper plate and tightened with screw. After setting of the pattern resin, the screws were loosened and pattern resin was removed from plate. Now the pattern resin was ready for splinting. The custom made mould was used to standardize the thickness of pattern resin, with 2mm thickness which was used in this study. This mould was used to minimize the polymerization shrinkage of pattern resin. The length is cut according to inter implant distance between implants placed in the reference model.

IV. CUSTOM TRAYS FABRICATION:

a. Preparation of primary cast:

Four impression copings were screwed onto the implant replicas of the reference model at a torque of 15Ncm using a manual torque wrench. An irreversible hydrocolloid impression was made and the impression coping was repositioned in the impression. Stone cast was obtained using type IV dental stone. This cast was used as the primary cast **(Fig: 30)**.

b. Preparation of spaced primary cast:

To maintain the uniform thickness of the special tray, spacer of 2mm thickness with modelling wax was adapted and two tissue stops were cut **(Fig:31)**. An impression of this primary cast with wax spacer was made using irreversible hydrocolloid and a cast was poured using type IV dental stone to obtain a spaced primary cast. All the custom trays to be used in this study were fabricated using the spaced primary cast for open tray impression techniques.

c. Fabrication of custom tray:

20 custom trays, for open tray impression technique were fabricated using cold cure polymerising acrylic resin. The open tray was fabricated using flasking method **(Fig: 33)**. The putty index was made over primary cast. Then conventional flasking procedure was carried (**Fig: 32**). After the gypsum products set, flask counterpart was opened and cold cure acrylic resin was mixed and packed over the cast and flask was closed ,tightened with clamp. After 30 minutes of curing, deflasking was done. Excess material was trimmed and open tray window was created on the anterior part of the tray. The finger rest were placed in lingual side of anterior part of the tray. In this manner, 20 custom trays were made (**Fig: 16**). All the trays were left undisturbed for 24 hours, to minimize polymerisation shrinkage prior to impression making.

d. Grouping of the samples:

A total of twenty custom trays were fabricated, of these ten samples were designated as group I, and other ten samples as group II, The samples within group I and II were further randomly divided into group I (A) and II(A), and I(B) and II (B) based on impression and splinting material. Open tray impression copings were screwed into implant analog at 15Ncm torque.

GROUP- I (A) : Direct impression technique with open tray impression copings splinted with prefabricated pattern resin and final impression was made using Vinyl Poly Siloxane impression material.

GROUP-II (A) : Direct impression technique with open tray impression copings splinted with prefabricated pattern resin and final impression is made using Vinyl Polyether Silicone impression material.

GROUP- I (B) : Direct impression technique with open tray impression copings splinted with Bis-GMA and final impression is made using Vinyl Poly Siloxane impression material.

GROUP- II (B) : Direct impression technique with open tray impression copings splinted with Bis-GMA and final impression is made using Vinyl Polyether Silicone impression material.

Total of 20 master casts were made. Evaluation of casts using coordinate measuring machine.

The open tray impression copings with long guide pins were screwed onto the implant replicas of the reference model at a torque of 15Ncm using the calibrated manual torque wrench. The Prefabricated pattern resin was made from custom made mould before 24hours and that was splinted to impression coping using brush bead technique at the time of impression making (**Fig:33**). After the polymerisation the putty index was made over pattern resin splinting in order to maintain the same thickness of 2mm which was used for splinting the Bis GMA splinting material (**Fig:34**).

The custom tray were coated with a tray adhesive and allowed to dry prior to impression making. VPS monophase and VPES heavy body and light body both were loaded separately on the respective custom tray. The tray was then positioned over and seated on to the reference model and the impression was made.

It was made sure that the tray was seated completely in the two stoppers that were made in the reference model to ensure complete seating and proper positioning of the custom tray. The excess material that had flown over the top of the posts through the window in the custom tray was removed to expose the screws. The impression was allowed to set undisturbed according to the manufacturer's recommendation. After ensuring the complete set of impression material, the long guide pin of the impression coping were unscrewed and the impression was removed from the reference model **(Fig: 36)**. A total of twenty impressions were made for the four groups in the same manner.

V. PREPARATION OF MASTER CASTS:

After the impressions were made, the casts were poured after half an hour as per manufacturer's recommendation. Implant replicas were screwed onto the impression posts that were picked in the open tray impressions. Casts were poured using die stone. The die stone was vaccum mixed with water as per the manufacturer's recommendation ratio of 100 gram to 20ml and vibrated in a vibrator to minimize air bubble incorporation. The same quantity of die stone was used for pouring all the casts. The cast was allowed to set for one hour and later retrieved from the impressions. For all the open tray impressions, the impression copings were unscrewed before retrieval of the cast **(Fig: 37)**. All casts were labelled 1 to 5 according to the group. A total of 20 master casts were thus obtained, grouping of samples done.

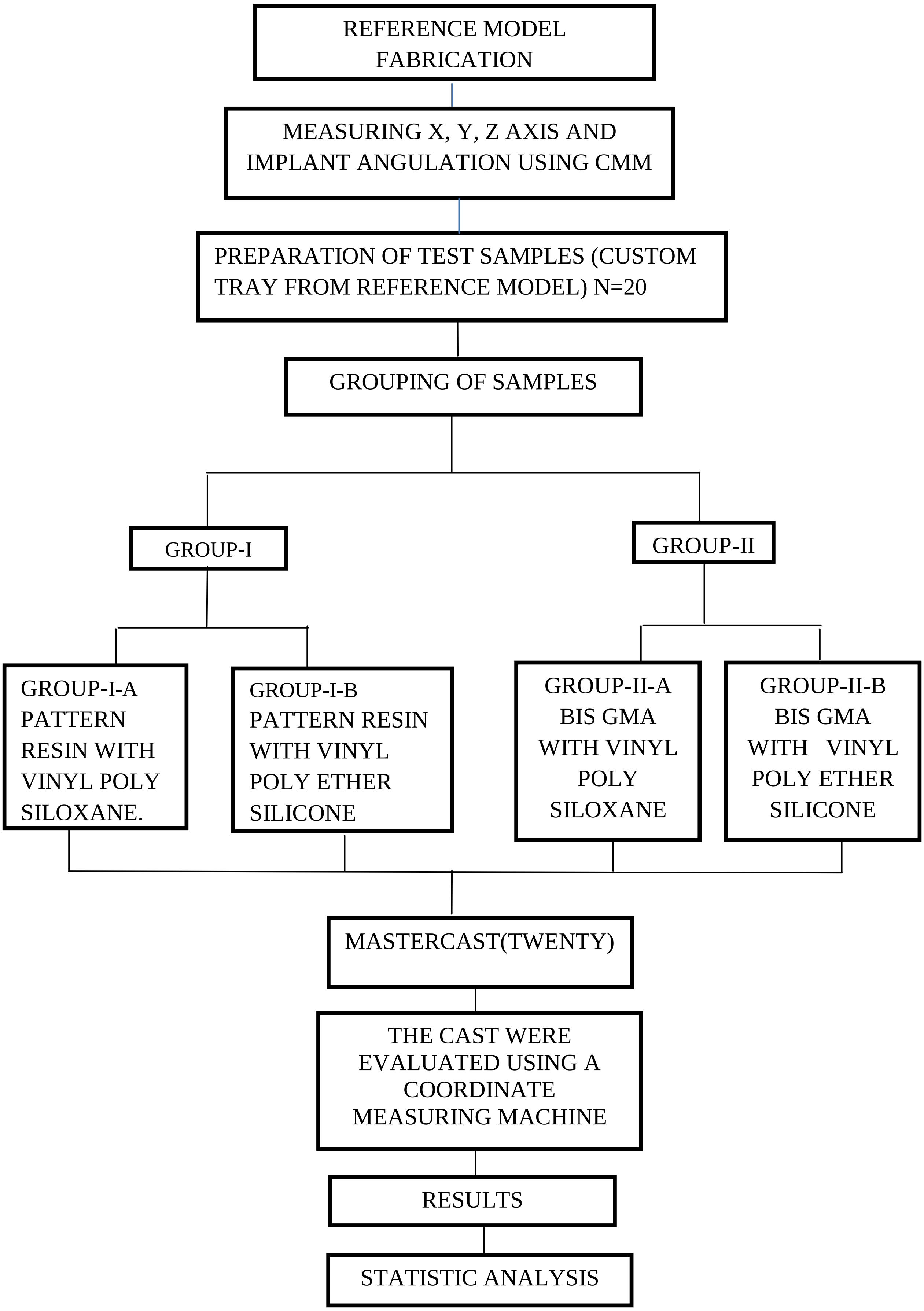
VI. EVALUATION OF MASTER CASTS USING COORDINATE MEASURING MACHINE:

The casts obtained from the different impressions were grouped according to the respective techniques and numbered from 1 to 5 in each group. All 20 casts of Group A and Group B were evaluated using a Coordinate measuring machine **(Fig:23)** (CMM, tespa, chennai, India) in a similar manner as it was done for the reference model. The measurements were made in all the three axes namely x, y and z.

VII. RESULTS AND STATISTICAL ANALYSIS:

The mean values of all the measurements for each group were obtained and they were statistically analysed using one way ANOVA and Post hoc tests at a significance of 0.5 using SPSS 20.0 software, tabulated and inferences drawn.

METHODOLOGY-OVERVIEW



Figures

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Fig:3 Cold Cure Acrylic Resin

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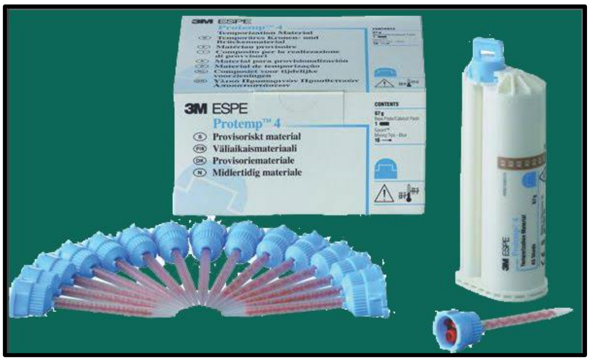

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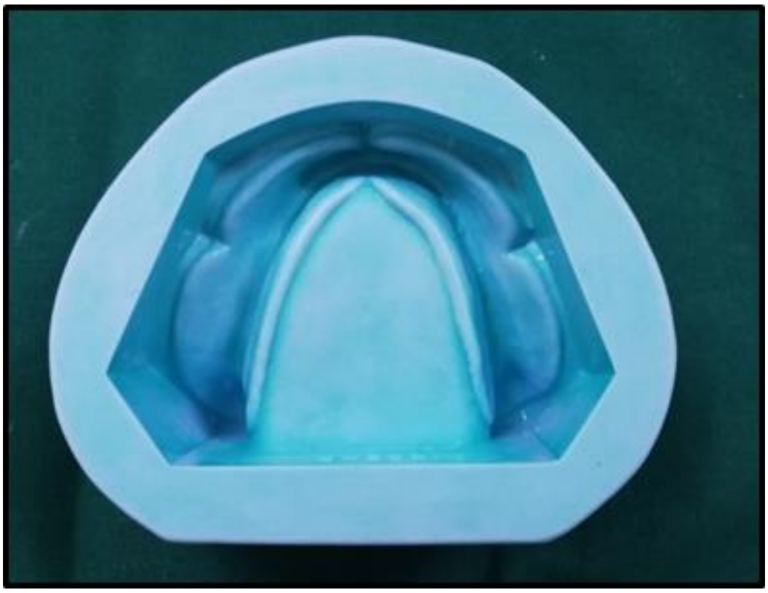

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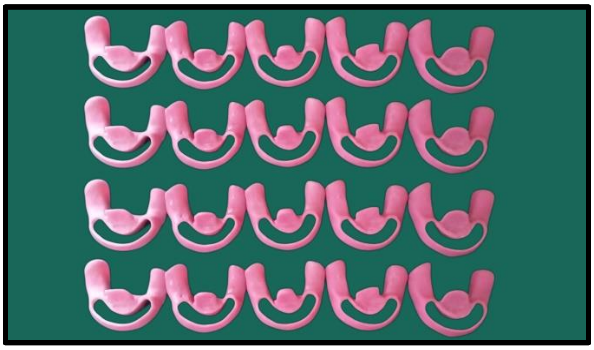

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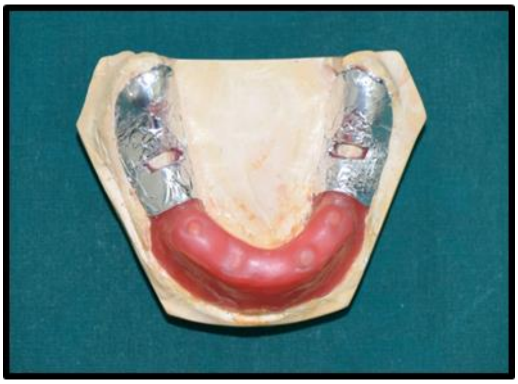


Fig:31A 2mm thickness of wax spacer was

adapted over the Primary Cast.

Fig:32 Conventional Flaskingproceduredone for primary cast.

Fig:33 Reference model was splinted with pattern resin

Fig:34 Putty index

Fig:35 Reference model was splinted with BisGMA Material

Fig:36 Impression made with VPS(Monophase) and VPES(Heavy body,Light body) are removed from the reference model.

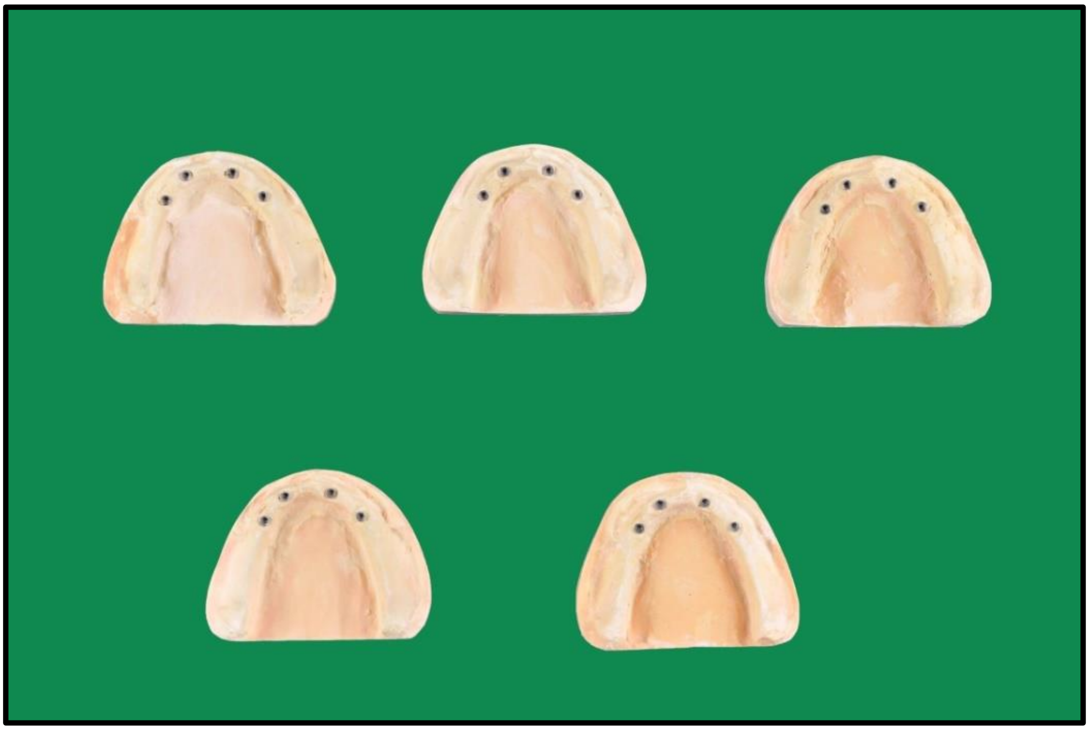


Fig:37 Master Cast.

Fig:38 Co-ordinate Measuring Machine

Fig:39 Measuring from implant replica 1 is taken as zero.

Fig:40 Measuring in implant replica4 as D3.

Results

RESULTS

The aim of present in vitro study was conducted to compare and evaluate the positional accuracy of implants with different splinting materials using two different elastomeric impression materials.

Twenty cast were made of which ten casts were obtained using pattern resin splinting material, and VPS and VPES as impression material and ten casts were obtained using BisGMA splinting material, VPS and VPES as impression material. The samples were divided into four groups were comprising of five casts each. The groups were designated as group I(A), II(A), I(B) & II(B).

Group I (A): Pattern resin as splinting material and VPS as impression material were used.

Group II (A): Pattern resin as splinting material and VPES as impression material were used.

Group I (B) : BisGMA as splinting material and VPS as impression material were used.

Group II (B) : BisGMA as splinting material and VPES as impression material were used.

The following results were obtained from the study which compared the inter implant distances in x, y and z axis and the angular relationships of the implants to horizontal plane in z axis using co-ordinate measuring machine. These four parameters were compared between the reference model and test groups (Group I(A), Group II(A), Group I(B) and Group II(B)). Mean and standard deviation (S.D) of all the values for each group were obtained and they were statistically analysed by using one way ANOVA and Post hoc test.

The following results were drawn from the study:

Table:1 to 16 Shows Basic Values, Mean And Standard Deviation Of Inter Implant Distance In X-Axis, Y-Axis, Z-Axis and Implant Angulation for the Group I (A),Group II (A),Group I (B),Group II (B) Samples (values in mm) and (Values in Degree)

Table:17 to 20 Shows Difference in Inter-Implant distance in X-Axis, Y-Axis, Z-Axis (Values in mm) and Implant angulation to Horizontal Plane in Z-Axis (Values in Degree)

Table: 21 to24Shows Comparison of Inter-Implant Distance in X-Axis, Y-Axis, Z-Axis (Values in mm) and Implant angulation to Horizontal Plane in Z-Axis (Values in Degree

TABLE:1 BASIC VALUES, MEAN AND STANDARD DEVIATION OF INTER IMPLANT DISTANCE IN X-AXIS FOR THE GROUP I (A) SAMPLES.

SAMPLES	1	2	3	4	5	MEAN/SD
D_1X(mm)	7.375	7.568	7.238	8.151	7.001	**7.466/0.434**
D_2X(mm)	23.502	23.665	23.404	24.507	23.242	**23.664/0.495**
D_3X(mm)	34.286	34.284	34.217	34.444	34.202	**34.286/0.0958**

INFERENCE:

D_1X – distance between replica 1 and replica 2 in X-axis

D_2X – distance between replica 1 and replica 3 in X-axis

D_3X – distance between replica 1 and replica 4 in X-axis

For Group I (A) samples, the mean inter implant distance in x-axis, between replica 1 and replica 2 (D_1X) is **7.466 mm**, between replica 1 and replica 3 (D_2X) is **23.664 mm** and between replica 1 and replica 4 (D_3X) is **34.286 mm**.

TABLE:2 BASIC VALUES, MEAN AND STANDARD DEVIATION OF INTER IMPLANT DISTANCE IN Y-AXIS FOR THE GROUP I (A) SAMPLES.

SAMPLES	1	2	3	4	5	MEAN/SD
D_1Y(mm)	9.072	8.618	9.258	8.116	9.299	**8.872/0.501**
D_2Y(mm)	9.464	8.779	9.640	11.159	9.343	**9.677/0.888**
D_3Y(mm)	1.498	0.840	2.372	2.278	1.498	**1.129/2.104**

INFERENCE:

D_1Y – distance between replica 1 and replica 2 in Y-axis

D_2Y – distance between replica 1 and replica 3 in Y-axis

D_3Y – distance between replica 1 and replica 4 in Y-axis

For Group I (A) samples, the mean inter implant distance in Y-axis, between replica 1 and replica 2 (D_1Y) is **8.872 mm**, between replica 1 and replica 3 (D_2Y) is **9.677 mm** and between replica 1 and replica 4 (D_3Y) is **1.129 mm**.

TABLE:3 BASIC VALUES, MEAN AND STANDARD DEVIATION OF INTER IMPLANT DISTANCE IN Z-AXIS FOR THE GROUP I (A) SAMPLES.

SAMPLES	1	2	3	4	5	MEAN/SD
D_1Z(mm)	-0.950	-0.454	-2.074	-1.011	0.661	**-0.902/1.074**
D_2Z(mm)	-3.331	-3.230	-4.536	-4.224	-4.237	**-3.911/0.590**
D_3Z(mm)	0.652	1.073	1.064	1.180	0.716	**0.937/0.236**

INFERENCE:

D_1Z – distance between replica 1 and replica 2 in Z-axis

D_2Z– distance between replica 1 and replica 3 in Z-axis

D_3Z – distance between replica 1 and replica 4 in Z-axis

For Group I (A) samples, the mean inter implant distance in Z-axis, between replica 1 and replica 2 (D_1Z) is **-0.902 mm**, between replica 1 and replica 3 (D_2Z) is **-3.911 mm** and between replica 1 and replica 4 (D_3Z) is **0.937 mm**.

TABLE:4 BASIC VALUES, MEAN AND STANDARD DEVIATION OF IMPLANT ANGULATION TO HORIZONTAL PLANE IN Z-AXIS FOR THE GROUP I (A) SAMPLES. (IN DEGREES)

SAMPLES	1	2	3	4	5	MEAN/SD
ANGLE 1 (Degree)	78.40	73.13	73.14	74.13	70.05	**73.860/2.873**
ANGLE 2 (Degree)	76.18	76.27	74.08	76.19	74.49	**75.442/1.066**
ANGLE 3 (Degree)	71.58	76.02	73.25	75.15	72.27	**73.704/1.965**
ANGLE 4 (Degree)	81.39	82.19	81.01	82.38	77.11	**80.602/2.146**

INFERENCE:

Angle 1 is replica, Angle 2 is replica 2,Angle 3 is replica 3,Angle4 is replica 4.

For Group I (A) samples, the mean implant angulations to horizontal plane in z-axis replica 1 (Angle 1) is **73.860 degrees,** replica 2 (Angle 2) is 75.442 **degrees**, replica 3 (Angle 3) is **73.704 degrees**, replica 4 (Angle 4) is **80.602 degrees**.

TABLE:5 BASIC VALUES, MEAN AND STANDARD DEVIATION OF INTER IMPLANT DISTANCE IN X-AXIS FOR THE GROUP II (A) SAMPLES.

SAMPLES	1	2	3	4	5	MEAN/SD
D_1X(mm)	7.765	7.679	7.278	6.778	7.479	**7.395/0.393**
D_2X(mm)	23.521	23.211	23.471	23.551	23.871	**23.525/0.235**
D_3X(mm)	34.151	34.394	34.359	34.366	34.925	**34.239/0.200**

INFERENCE:

D_1X – distance between replica 1 and replica 2 in X-axis

D_2X – distance between replica 1 and replica 3 in X-axis

D_3X – distance between replica 1 and replica 4 in X-axis

For Group II (A) samples, the mean inter implant distance in x-axis, between replica 1 and replica 2 (D_1X) is **7.395 mm**, between replica 1 and replica 3 (D_2X) is **23.525 mm** and between replica 1 and replica 4 (D_3X) is **34.239 mm**.

TABLE:6 BASIC VALUES, MEAN AND STANDARD DEVIATION OF INTER IMPLANT DISTANCE IN Y-AXIS FOR THE GROUP II(A) SAMPLES.

SAMPLES	1	2	3	4	5	MEAN/SD
D_1Y(mm)	8.561	9.249	8.430	8.928	8.562	**8.746/0.227**
D_2Y(mm)	9.742	9.464	10.332	6.968	10.685	**9.438/1.461**
D_3Y(mm)	0.772	0.466	1.248	1.968	0.796	**1.050/0.584**

INFERENCE:

D_1Y – distance between replica 1 and replica 2 in Y-axis

D_2Y – distance between replica 1 and replica 3 in Y-axis

D_3Y – distance between replica 1 and replica 4 in Y-axis

For Group II (A) samples, the mean inter implant distance in Y-axis, between replica 1 and replica 2 (D_1Y) is **8.746 mm**, between replica 1 and replica 3 (D_2Y) is **9.438 mm** and between replica 1 and replica 4 (D_3Y) is **1.050 mm.**

TABLE:7 BASIC VALUES, MEAN AND STANDARD DEVIATION OF INTER IMPLANT DISTANCE IN Z-AXIS FOR THE GROUP II(A) SAMPLES.

SAMPLES	1	2	3	4	5	MEAN/SD
D_1Z(mm)	-2.244	1.099	-0.511	-1.122	-1.282	**-0.812/1.235**
D_2Z(mm)	-6.832	0.500	-4.561	-4.145	-4.674	**-3.942/2.694**
D_3Z(mm)	1.876	1.027	-1.621	1.851	0.441	**0.714/1.437**

INFERENCE:

D_1Z – distance between replica 1 and replica 2 in Z-axis

D_2Z– distance between replica 1 and replica 3 in Z-axis

D_3Z – distance between replica 1 and replica 4 in Z-axis

For Group II (A) samples, the mean inter implant distance in Z-axis, between replica 1 and replica 2 (D_1Z) is **-0.812 mm**, between replica 1 and replica 3 (D_2Z) is **-3.942mm** and between replica 1 and replica 4 (D_3Z) is **0.714 mm.**

TABLE:8 BASIC VALUES, MEAN AND STANDARD DEVIATION OF IMPLANT ANGULATION TO HORIZONTAL PLANE IN Z-AXIS FOR THE GROUP II (A) SAMPLES. (IN DEGREES)

SAMPLES	1	2	3	4	5	MEAN/SD
ANGLE 1 (Degree)	75.58	74.45	74.00	74.22	76.00	**74.850/0.885**
ANGLE 2 (Degree)	77.11	74.35	74.51	74.56	74.10	**74.926/1.233**
ANGLE 3 (Degree)	77.17	77.11	77.47	75.15	75.16	**76.412/1.555**
ANGLE 4 (Degree)	82.04	81.04	82.31	82.40	83.41	**81.840/1.166**

INFERENCE:

Angle 1 is replica 1, Angle 2 is replica 2, Angle3 is replica 3, Angle4 is replica 4

For Group II (A) samples, the mean implant angulations to horizontal plane in z-axis replica1 (Angle1) is **74.850 degrees**, replica2 (Angle2) is **74.929 degrees**, replica3 (Angle 3) is **76.412 degrees**, replica 4 (Angle 4) is **81.840 degrees**.

TABLE:9 BASIC VALUES, MEAN AND STANDARD DEVIATION OF INTER IMPLANT DISTANCE IN X-AXIS FOR THE GROUP I (B) SAMPLES

SAMPLES	1	2	3	4	5	MEAN/SD
D_1X	7.557	7.398	7.710	7.350	7.668	**7.536/0.159**
D_2X	23.768	24.036	23.800	23.083	23.817	**23.700/0.361**
D_3X	34.238	34.230	34.271	34.090	34.501	**34.266/0.148**

INFERENCE:

D_1X – distance between replica 1 and replica 2 in X-axis

D_2X – distance between replica 1 and replica 3 in X-axis

D_3X – distance between replica 1 and replica 4 in X-axis

For Group I (B) samples, the mean inter implant distance in x-axis, between replica 1 and replica 2 (D_1X) is **7.536 mm**, between replica 1 and replica 3 (D_2X) is **23.700 mm** and between replica 1 and replica 4 (D_3X) is **34.266 mm**.

TABLE:10 BASIC VALUES, MEAN AND STANDARD DEVIATION OF INTER IMPLANT DISTANCE IN Y-AXIS FOR THE GROUP I (B) SAMPLES.

SAMPLES	1	2	3	4	5	MEAN/SD
D_1Y(mm)	9.134	8.992	8.835	9.147	8.716	**8.938/0.163**
D_2Y(mm)	10.660	10.488	9.781	10.002	9.566	**10.099/0.463**
D_3Y(mm)	2.626	2.613	1.714	1.988	1.312	**2.050/0.572**

INFERENCE:

D_1Y – distance between replica 1 and replica 2 in Y-axis

D_2Y – distance between replica 1 and replica 3 in Y-axis

D_3Y – distance between replica 1 and replica 4 in Y-axis

For Group I (B) samples, the mean inter implant distance in Y-axis, between replica 1 and replica 2 (D_1Y) is **8.938 mm**, between replica 1 and replica 3 (D_2Y) is **10.099mm** and between replica 1 and replica 4 (D_3Y) is **2.050 mm**

TABLE:11 BASIC VALUES, MEAN AND STANDARD DEVIATION OF INTER IMPLANT DISTANCE IN Z-AXIS FOR THE GROUP I (B) SAMPLES

SAMPLES	1	2	3	4	5	MEAN/SD
D_1Z(mm)	-1.054	-0.779	-0.582	-0.901	-1.331	**-0.929/0.283**
D_2Z(mm)	-3.545	-3.438	-3.561	-3.501	-3.847	**-3.608/0.153**
D_3Z(mm)	1.661	-2.131	-2.374	0.463	0.347	**-0.406/1.763**

INFERENCE:

D_1Z – distance between replica 1 and replica 2 in Z-axis

D_2Z– distance between replica 1 and replica 3 in Z-axis

D_3Z – distance between replica 1 and replica 4 in Z-axis

For Group I (B) samples, the mean inter implant distance in Z-axis, between replica 1 and replica 2 (D_1Z) is **-0.929 mm**, between replica 1 and replica 3 (D_2Z) is **-3.608mm** and between replica 1 and replica 4 (D_3Z) is **-0.406 mm**.

TABLE:12 BASIC VALUES, MEAN AND STANDARD DEVIATION OF IMPLANT ANGULATION TO HORIZONTAL PLANE IN Z-AXIS FOR THE GROUP I (B) SAMPLES. (IN DEGREES)

SAMPLES	1	2	3	4	5	MEAN/SD
ANGLE 1 (Degree)	74.46	78.41	78.40	73.05	75.51	**75.966/2.391**
ANGLE 2 (Degree)	76.34	81.29	79.49	75.22	78.54	**78.160/2.421**
ANGLE 3 (Degree)	73.14	78.48	79.12	75.32	77.05	**76.637/2.506**
ANGLE 4 (Degree)	80.37	83.10	84.31	80.27	83.56	**82.322/1.878**

INFERENCE:

Angle 1 is replica 1,Angle 2 is replica 2,Angle 3 is replica 3, Angle 4 is replica 4 For Group I (B) samples, the mean implant angulations to horizontal plane in z-axis replica 1 (Angle 1) is **75.966 degrees**, replica 2 (Angle 2) is **78.160 degrees**, replica3 (Angle 3) is **76.637 degrees**, replica 4 (Angle 4) is **82.322 degrees**.

TABLE: 13 BASIC VALUES, MEAN AND STANDARD DEVIATION OF INTER IMPLANT DISTANCE IN X-AXIS FOR THE GROUP II (B) SAMPLES.

SAMPLES	1	2	3	4	5	MEAN/SD
D_1X	7.741	7.648	7.521	7.554	7.718	**7.636/0.097**
D_2X	23.687	23.679	23.919	23.523	23.513	**23.664/0.164**
D_3X	34.151	34.394	34.359	34.366	33.925	**34.347/0.118**

INFERENCE:

D_1X – distance between replica 1 and replica 2 in X-axis

D_2X – distance between replica 1 and replica 3 in X-axis

D_3X – distance between replica 1 and replica 4 in X-axis

For Group II (B) samples, the mean inter implant distance in x-axis, between replica 1 and replica 2 (D_1X) is **7.636 mm**, between replica 1 and replica 3 (D_2X) is **23.664 mm** and between replica 1 and replica 4 (D_3X) is **34.347 mm**.

TABLE: 14 BASIC VALUES, MEAN AND STANDARD DEVIATION OF INTER IMPLANT DISTANCE IN Y-AXIS FOR THE GROUP II (B) SAMPLES.

SAMPLES	1	2	3	4	5	MEAN/SD
D_1Y(mm)	9.066	8.553	8.571	8.949	9.141	**8.856/0.336**
D_2Y(mm)	10.244	10.808	9.450	10.682	9.073	**10.051/0.762**
D_3Y(mm)	2.341	2.750	1.087	2.758	0.915	**1.970/0.902**

INFERENCE:

D_1Y – distance between replica 1 and replica 2 in Y-axis

D_2Y – distance between replica 1 and replica 3 in Y-axis

D_3Y – distance between replica 1 and replica 4 in Y-axis

For Group II (B) samples, the mean inter implant distance in Y-axis, between replica 1 and replica 2 (D_1Y) is **8.856 mm**, between replica 1 and replica 3 (D_2Y) is **10.051mm** and between replica 1 and replica 4 (D_3Y) is **1.970 mm**.

TABLE: 15 BASIC VALUES, MEAN AND STANDARD DEVIATION OF INTER IMPLANT DISTANCE IN Z-AXIS FOR THE GROUP II (B) SAMPLES

SAMPLES	1	2	3	4	5	MEAN/SD
D_1Z(mm)	-1.113	-0.869	-0.531	-1.026	-0.865	**-0.880/0.222**
D_2Z(mm)	-3.680	-3.356	-3.045	-3.363	-3.369	**-3.422/0.254**
D_3Z(mm)	0.738	0.765	0.358	0.165	0.640	**0.533/0.261**

INFERENCE:

D_1Z – distance between replica 1 and replica 2 in Z-axis

D_2Z– distance between replica 1 and replica 3 in Z-axis

D_3Z – distance between replica 1 and replica 4 in Z-axis

For Group II (B) samples, the mean inter implant distance in Z-axis, between replica 1 and replica 2 (D_1Z) is **-0.880 mm**, between replica 1 and replica 3 (D_2Z) is **-3.422mm** and between replica 1 and replica 4 (D_3Z) is **0.533 mm**.

TABLE: 16 BASIC VALUES, MEAN AND STANDARD DEVIATION OF IMPLANT ANGULATION TO HORIZONTAL PLANE IN Z-AXIS FOR THE GROUP II (B) SAMPLES. (IN DEGREES)

SAMPLES	1	2	3	4	5	MEAN/SD
ANGLE 1 (Degree)	75.01	77.50	74.35	74.02	83.23	**76.822/3.833**
ANGLE 2 (Degree)	76.26	79.17	76.30	77.15	85.15	**78.806/3.737**
ANGLE 3 (Degree)	74.49	78.54	73.41	77.49	85.57	**77.900/4.774**
ANGLE 4 (Degree)	82.34	85.02	80.04	82.07	83.57	**82.608/1.850**

INFERENCE:

Angle 1 is replica 1, Angle 2 is replica 2, Angle3 is replica 3,Angle4 is replica 4

For Group II (B) samples, the mean implant angulations to horizontal plane in z-axis replica 1 (Angle 1) is **76.822 degrees**, replica 2 (Angle 2) is **78.806 degrees**, replica 3(Angle 3) is **77.900 degrees**, replica 4 (Angle 4) is **82.608 degrees**.

TABLE: 17 DIFFERENCE IN INTER-IMPLANT DISTANCE IN X-AXIS (values in mm)

GROUPS	Δ D_1X		Δ D_2X		Δ D_3X	
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**
GROUP I (A)	0.07860	0.434	0.16	0.496	0.0616	0.095
GROUP II (A)	0.00720	0.393	0.023	0.235	0.1222	0.118
GROUP I (B)	0.14860	0.159	0.198	0.361	0.0410	0.1485
GROUP II (B)	0.2488	0.097	0.1628	0.164	0.0140	0.200

INFERENCE:

D_1X – distance between replica 1 and replica 2 in X-axis

D_2X – distance between replica 1 and replica 3 in X-axis

D_3X – distance between replica 1 and replica 4 in X-axis

On comparison of the difference in mean inter implant distances in X-axis with reference model, group I (A), group II (A), group I (B), group II (B) were not statistically significant. Group II (A) shows minimum distortion value in comparison with other groups.

TABLE: 18 DIFFERENCE IN INTER-IMPLANT DISTANCE IN Y-AXIS

(Values in mm)

GROUPS	Δ D_1Y		Δ D_2Y		Δ D_3Y	
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**
GROUP I (A)	0.1264	0.501	0.7250	0.8889	0.3895	1.266
GROUP II (A)	0.0000	0.3369	0.4862	1.461	0.3790	2.104
GROUP I (B)	0.1923	0.1636	1.147	0.4638	1.300	0.5723
GROUP II (B)	0.1100	0.2770	1.099	0.7625	1.220	0.9027

INFERENCE:

D_1Y – distance between replica 1 and replica 2 in Y-axis

D_2Y – distance between replica 1 and replica 3 in Y-axis

D_3Y – distance between replica 1 and replica 4 in Y-axis

On comparison of the difference in mean inter implant distances in Y-axis with reference model, group I (A), group II (A), group I (B), group II (B) were not statistically significant. Group II (A) shows minimum distortion value in comparison with other groups.

TABLE: 19 DIFFERENCE IN INTER-IMPLANT DISTANCE IN Z-AXIS

(Values in mm)

GROUPS	Δ D_1Z		Δ D_2Z		Δ D_3Z	
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**
GROUP I (A)	0.274	1.074	1.732	1.860	-0.358	1.277
GROUP II(A)	0.247	0.283	0.013	0.590	0.264	0.236
GROUP I (B)	0.365	1.235	0.316	0.153	-1.079	1.763
GROUP II(B)	0.296	0.222	0.503	0.254	-0.139	0.261

INFERENCE:

D_1Z – distance between replica 1 and replica 2 in Z-axis

D_2Z– distance between replica 1 and replica 3 in Z-axis

D_3Z – distance between replica 1 and replica 4 in Z-axis

On comparison of the difference in mean inter implant distances in Z-axis with reference model, group I (A), group II (A), group I (B), group II (B) were not statistically significant. Group II (A) shows minimum distortion value in comparison with other groups.

TABLE:20 DIFFERENCE IN IMPLANT ANGULATION TO HORIZONTAL PLANE IN Z-AXIS (values in degree)

GROUPS	Δ Angle 1		Δ Angle 2		Δ Angle 3		Δ Angle 4	
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
GRSOUP (A)	-1.7200	2.873	-1.5580	1.066	5.222	1.965	-9.664	2.146
GROUP II(A)	-0.73	0.885	-2.0740	1.233	2.514	1.155	-8.640	1.166
GROUP I (B)	0.3860	2.391	1.160	2.421	5.486	2.506	-8.158	1.878
GROUP II(B)	1.242	3.833	1.806	3.737	6.710	4.778	-7.872	1.850

INFERENCE:

Angle 1 is replica 1

Angle 2 is replica 2

Angle 3 is replica 3

Angle 4 is replica 4

On comparison of the difference in mean implant angulation to horizontal plane in Z-axis with reference model, group I (A), group II (A), group I (B), group I (B) were not statistically significant. Group II (A) shows minimum distortion value in comparison with other groups.

TABLE: 21 COMPARISON OF INTER-IMPLANT DISTANCE IN X-AXIS (Values in mm)

GROUPS	D_1X		D_2X		D_3X	
	MEAN	**SD**	**MEAN**	**SD**	**MEAN**	**SD**
REFERENCE	7.388	0.000	23.502	0.000	34.225	0.000
GROUP I (A)	7.466	0.434	23.664	0.495	34.286	0.0958
GROUP II(A)	7.395	0.393	23.525	0.235	34.239	0.200
GROUP I (B)	7.536	0.159	23.700	0.361	34.266	0.1485
GROUP II(B)	7.636	0.097	23.664	0.164	34.347	0.1181
F-STATISTIC	**1.013**		**1.131**		**0.673**	
p-VALUE	**0.424**		**0.370**		**0.619**	

INFERENCE:

D_1X – distance between replica 1 and replica 2 in X-axis

D_2X – distance between replica 1 and replica 3 in X-axis

D_3X – distance between replica 1 and replica 4 in X-axis

1) For the group I (A) samples the mean inter implant distances in X-axis, between replica 1 and replica 2 (D_1X) is **7.466 mm**, between replica 1 and replica 3 (D_2X) is **23.664 mm** and between replica 1 and replica 4 (D_3X) is **34.286 mm.**

2) For the group II (A) samples the mean inter implant distances in X-axis, between replica 1 and replica 2 (D_1X) is **7.395 mm**, between replica 1 and replica 3 (D_2X) is **23.525mm** and between replica 1 and replica4(D_3X) is **34.239 mm.**

3) For the group I (B) samples the mean inter implant distances in X-axis, between replica 1 and replica 2 (D_1X) is **7.536 mm,** between replica 1 and replica 3 (D_2X) is **23.700mm** and between replica 1 and replica4 (D_3X) is **34.266 mm.**

4) For the group II (B) samples the mean inter implant distances in X-axis, between replica 1 and replica 2 (D_1X) is **7.636 mm**, between replica 1 and replica 3 (D_2X) is **23.664 mm** and between replica 1 and replica4 (D_3X) is **34.347 mm**

5) On comparison of the mean inter implant distances in X-axis (D_1X, D_2X and D_3X) between the reference and the test groups, results were found to be statistically not significant. There is a variation in values between the groups.

TABLE: 22 COMPARISON OF INTERIMPLANTDISTANCE IN Y-AXIS

(Value in mm)

GROUPS	D_1Y		D_2Y		D_3Y	
	MEAN	SD	MEAN	SD	MEAN	SD
REFERENCE	8.746	0.000	8.952	0.000	0.750	0.000
GROUP I (A)	8.872	0.501	9.677	0.888	1.129	2.104
GROUP II (A)	8.746	0.277	9.438	1.461	1.050	0.584
GROUP I (B)	8.938	0.163	10.099	0.463	2.050	0.572
GROUP II (B)	8.856	0.336	10.051	0.762	1.970	0.902
F-STATISTICS	**0.785**		**1.503**		**1.209**	
p-VALUE	**0.548**		**0.239**		**0.338**	

INFERENCE:

D_1Y – distance between replica 1 and replica 2 in Y-axis

D_2Y – distance between replica 1 and replica 3 in Y-axis

D_3Y – distance between replica 1 and replica 4 in Y-axis

1) For the group I (A) samples the mean inter implant distances in Y-axis, between replica1 and replica 2 (D_1Y) is **8.872 mm**, between replica 1 and replica 3 (D_2Y) is **9.677 mm** and between replica 1 and replica 4 (D_3Y) is **1.129 mm.**

2) For the group II (A) samples the mean inter implant distances in Y-axis, between replica 1 and replica 2 (D_1Y) is **8.746 mm**, between replica 1 and replica 3 (D_2Y) is **9.438 mm** and between replica 1 and replica 4 (D_3Y) is **1.129 mm**.
3) For the group I (B) samples the mean inter implant distances in Y-axis, between replica 1 and replica 2 (D_1Y) is **8.938 mm,** between replica 1 and replica 3 (D_2Y) is **10.099 mm** and between replica 1 and replica 4 (D_3Y) is **2.050 mm.**
4) For the group II (B) samples the mean inter implant distances in Y-axis, between replica 1 and replica 2 (D_1Y) is **8.856 mm**, between replica 1 and replica 3 (D_2Y) is **10.051 mm** and between replica 1 and replica 4 (D_3Y) is **1.970 mm**
5) On comparison of the mean inter implant distances in Y-axis (D_1Y, D_2Y and D_3Y) between the reference and the test groups, results were found to be statistically not significant.

TABLE: 23 COMPARISON OF INTER-IMPLANT DISTANCE IN Z-AXIS

(Values in mm)

GROUPS	D_1Z		D_2Z		D_3Z	
	MEAN	SD	MEAN	SD	MEAN	SD
REFERENCE	-1.177	0.000	-3.925	0.000	0.673	0.000
GROUP I (A)	-0.902	1.074	-3.911	0.590	0.937	0.236
GROUP II (A)	-0.812	1.235	-3.942	2.694	0.714	1.437
GROUP I (B)	-0.929	0.283	-3.608	0.153	-0.406	1.763
GROUP II (B)	-0.880	0.222	-3.422	0.254	0.533	0.261
F-STATISTIC	**0.172**		**3.269**		**1.333**	
p-VALUE	**0.950**		**0.032***		**0.292**	

p-Value<0.05* was considered as significant.

INFERENCE:

D_1Z – distance between replica 1 and replica 2 in Z-axis

D_2Z– distance between replica 1 and replica 3 in Z-axis

D_3Z – distance between replica 1 and replica 4 in Z-axis

1) For the group I (A) samples the mean inter implant distances in Z-axis, between replica 1 and replica 2 (D_1Z) is **-0.902 mm**, between replica 1 and replica 3 (D_2Z) is -**3.911mm** and between replica 1 and replica 4 (D_3Z) is **0.937 mm.**

2) For the group II (A) samples the mean inter implant distances in Z-axis, between replica 1 and replica 2 (D_1Z) is **-0.812 mm**, between replica 1 and replica 3 (D_2Z) is **-3.942 mm** and between replica 1 and replica4 (D_3Z) is **0.714 mm.**

3) For the group I (B) samples the mean inter implant distances in Z-axis, between replica 1 and replica 2 (D_1Z) is **-0.929 mm**, between replica 1 and replica 3 (D_2Z) is **- 3.608mm** and between replica 1 and replica 4 (D_3Z) is **-0.406 mm**.

4) For the group II (B) samples the mean inter implant distances in Z-axis, between replica 1 and replica 2 (D_1Z) is **-0.880 mm**, between replica 1 and replica 3 (D_2Z) is **-3.422mm** and between replica 1 and replica4 (D_3Z) is **0.533 mm.**

5) On comparison of the mean inter implant distances in Z-axis (D_1Z and D_3Z) between the reference and the test groups, results were found to be statistically not significant, while statistically significant values were found in D_2Z axis.

TABLE:24 COMPARISON OF IMPLANT ANGULATION TO HORIZONTAL PLANE IN Z AXIS (values in degree)

GROUPS	ANGLE-1		ANGLE-2		ANGLE-3		ANGLE-4	
	MEAN	**SD**	**MEAN**	**SD**	**MEAN**	**SD**	**MEAN**	**SD**
REFRENCE	75.580	0.000	77.000	0.000	71.190	0.000	90.480	0.000
GROUP I (A)	73.860	2.873	75.442	1.066	73.704	1.965	80.816	2.146
GROUP II (A)	74.850	0.885	74.926	1.233	76.412	1.555	81.840	1.166
GROUP I (B)	75.966	2.391	78.160	2.421	76.676	2.506	82.322	1.878
GROUP II (B)	76.822	3.833	78.806	3.737	77.900	4.774	82.608	1.850
F-STATISTIC	**1.071**		**3.125**		**5.333**		**29.408**	
p-VALUE	**0.397**		**0.038***		**0.004***		**0.000***	

p-Value<0.05* was considered as significant.

INFERENCE:

Angle 1 is replica 1

Angle 2 is replica 2

Angle 3 is replica 3

Angle 4 is replica 4

1) For the Group I(A) sample the implant angulation in angle 1 is **73.860 degree**, angle 2 is **74.850 degree**, angle 3 is **75.966 degree** and angle 4 is **76.822 degree**.

2) For the group II (A) sample the implant angulation in angle 1 is **74.850 degree**, angle 2 is **74.926 degree**, angle3 is **76.412 degree** and angle 4 is **81.840 degree.**
3) For the group I (B) sample the implant angulation in angle 1 is **75.966 degree**, angle 2 is **78.160 degree**, angle 3 is **76.676 degree** and angle 4 is **83.322 degree**.
4) For the Group II (B) sample the implant angulation in angle 1 is **76.822 degree**, angle 2 is **78.806 degree**, angle 3 is **77.900 degree** and angle 4 is **82.608 degree.**
5) On comparison, the mean inter implant angulation value in z-axis with that of reference model showed statistically significant difference with angle 2,3,4 values of group I (A),group II(A),group I(B),group II(B).While the value of angle 1 had no statistical significance in all the groups.

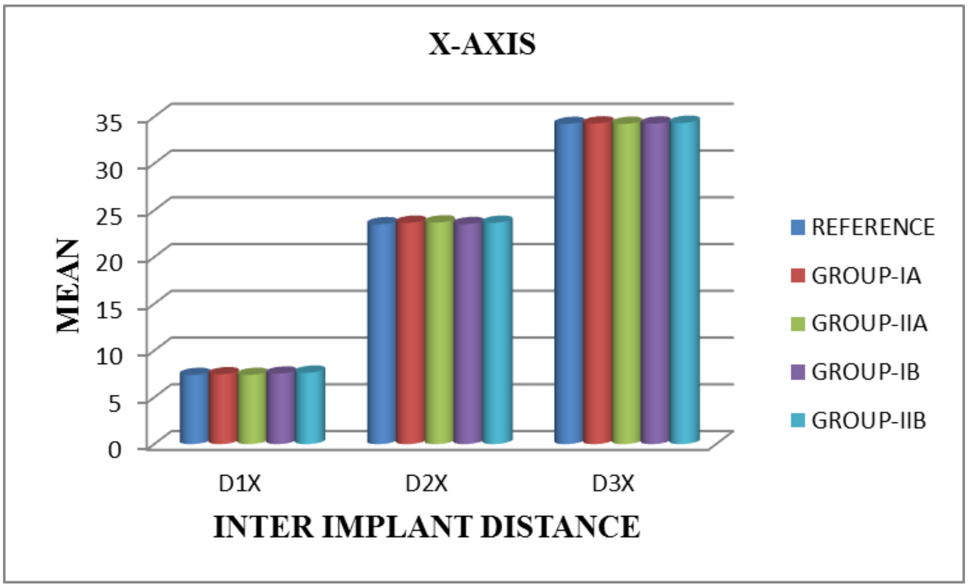
Observation from the study:

On comparison, of all the test groups the mean inter implant distance in all axis and implant angulations in Z-axis, Group II (A) shows nearest value to the reference model.

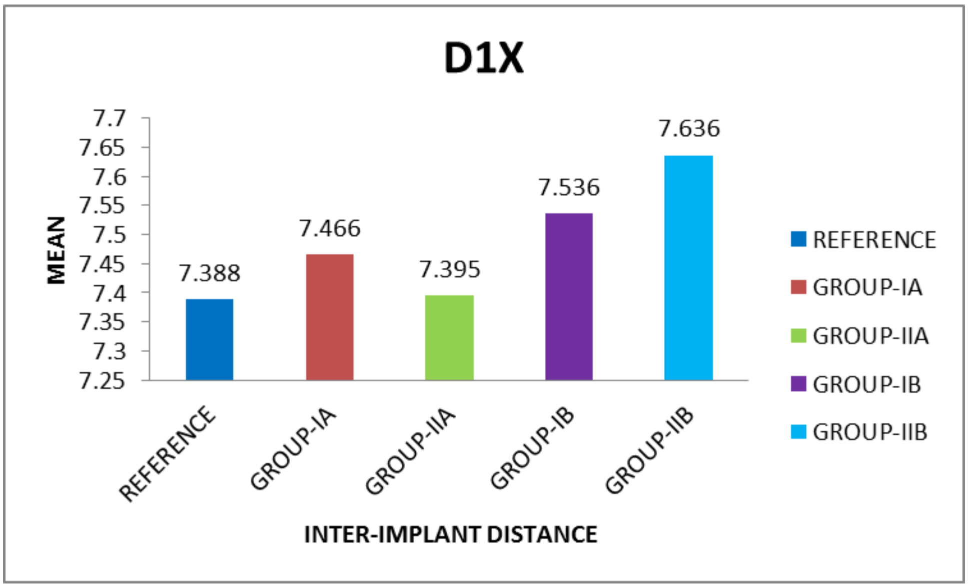
ANNEXRUE III

GRAPHS

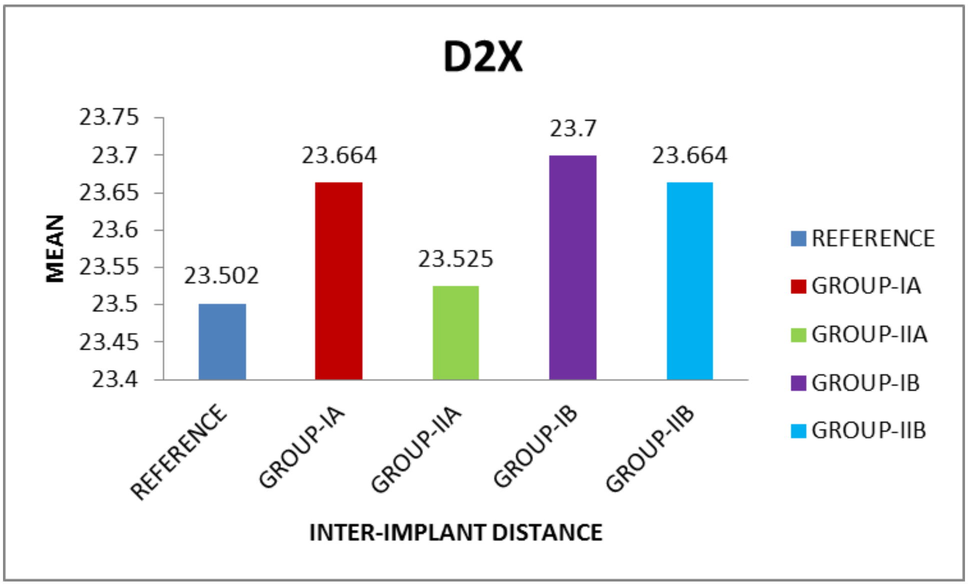
GRAPH: 1 COMPARISON OF INTER –IMPLANT DISTANCEIN X-AXIS



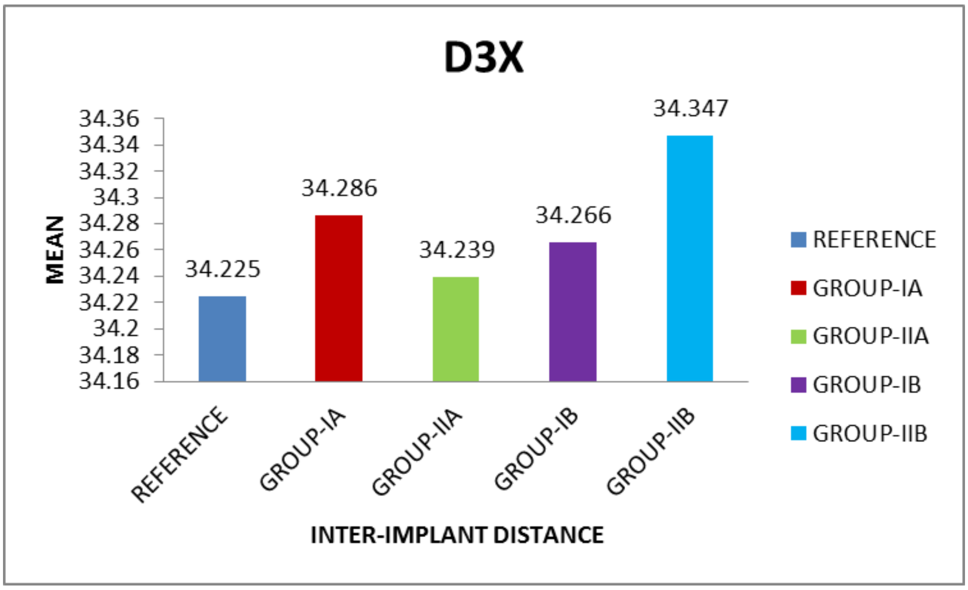
GRAPH: 2 COMPARISON OF INTER –IMPLANT DISTANCEIN D_1X-AXIS.



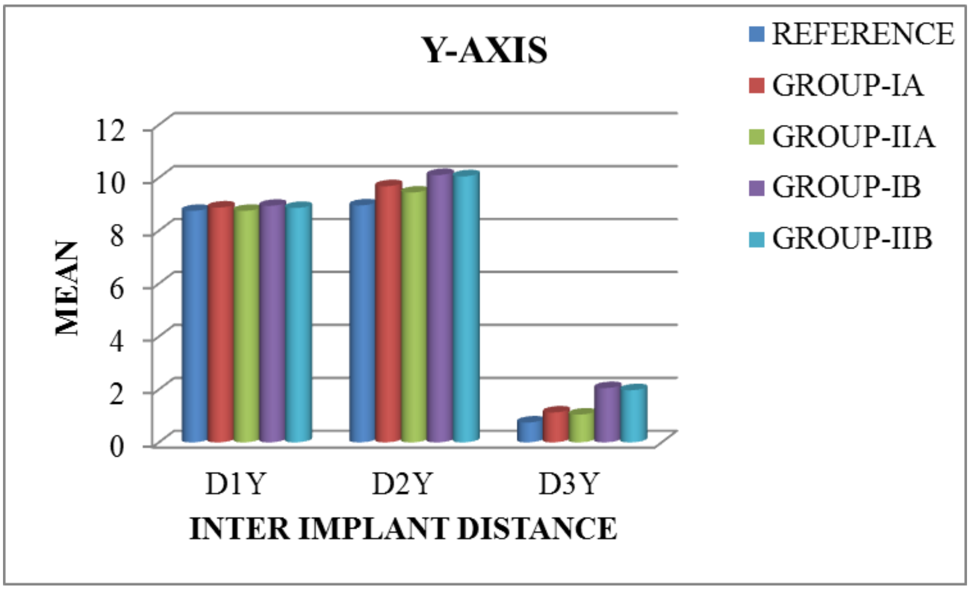
GRAPH: 3 COMPARISON OF INTER –IMPLANT DISTANCEIN D_2X-AXIS.



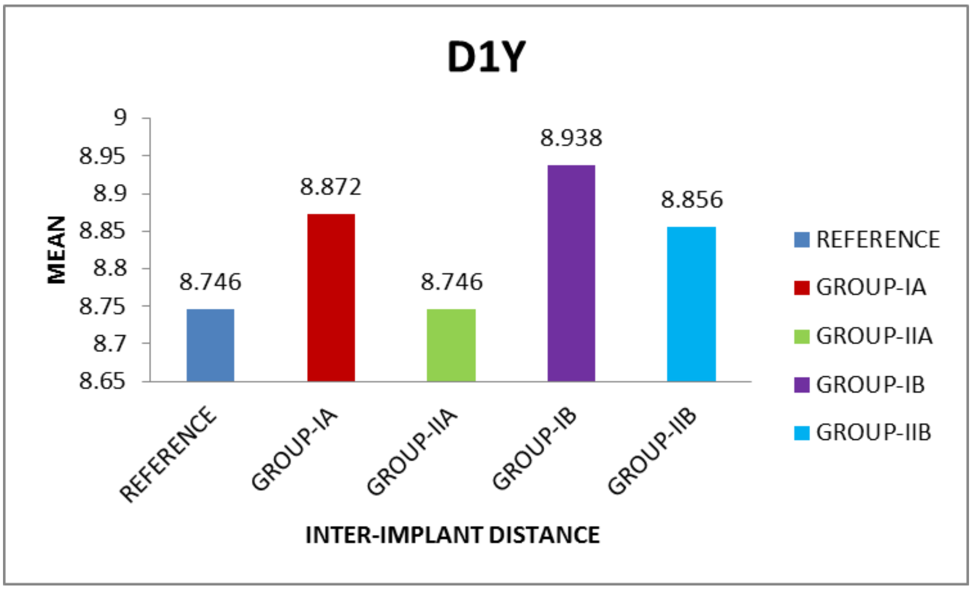
GRAPH: 4 COMPARISON OF INTER –IMPLANT DISTANCEIN D_3X-AXIS.



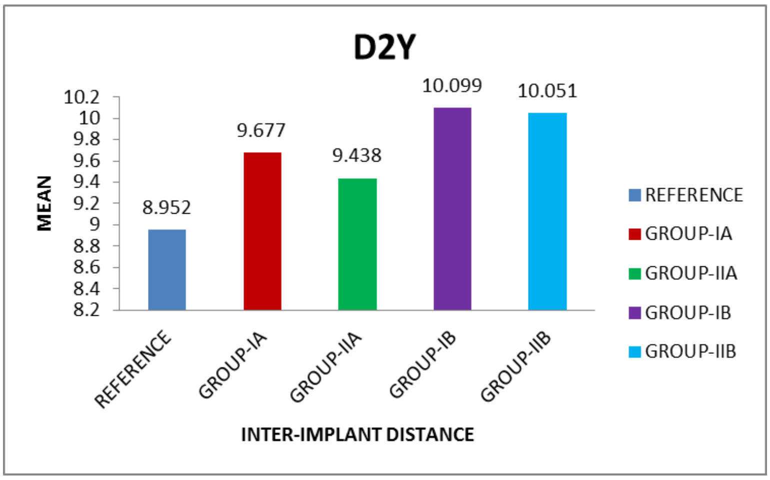
GRAPH: 5 COMPARISON OF INTER –IMPLANT DISTANCEIN Y-AXIS



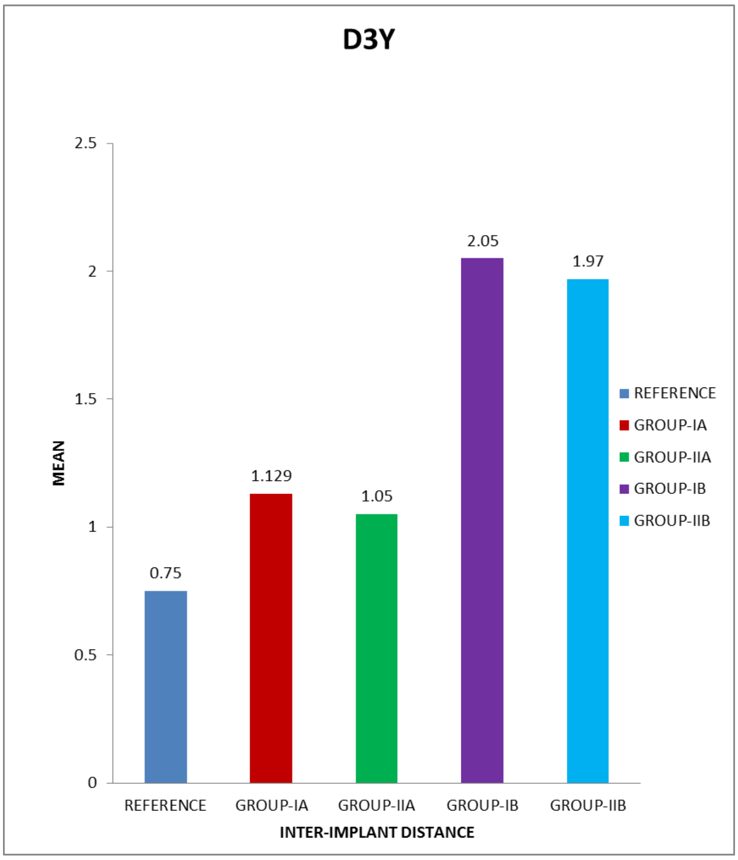
GRAPH: 6 COMPARISON OF INTER –IMPLANT DISTANCE IN D_1Y-AXIS



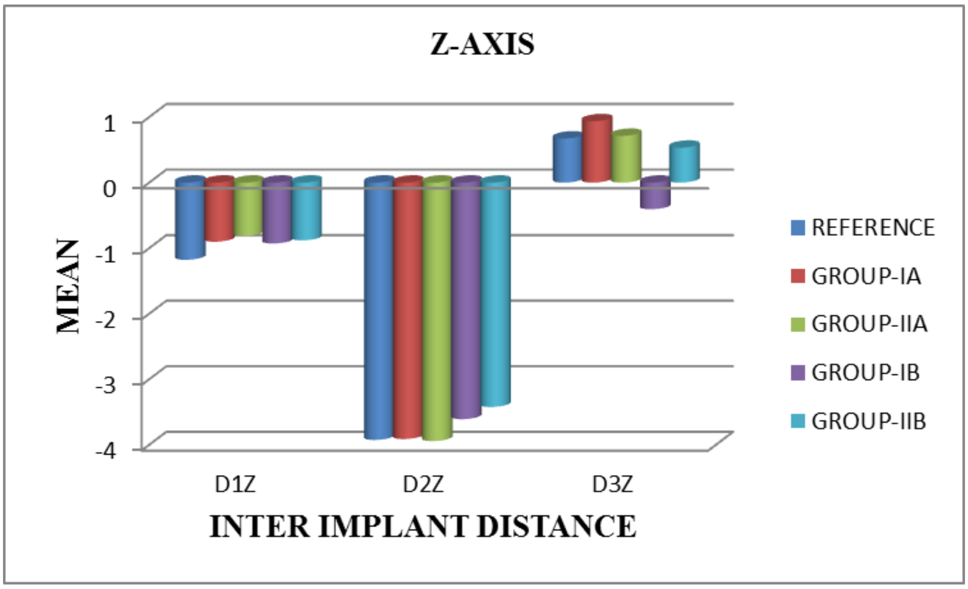
GRAPH: 7 COMPARISON OF INTER –IMPLANT DISTANCE IN D_2Y-AXIS



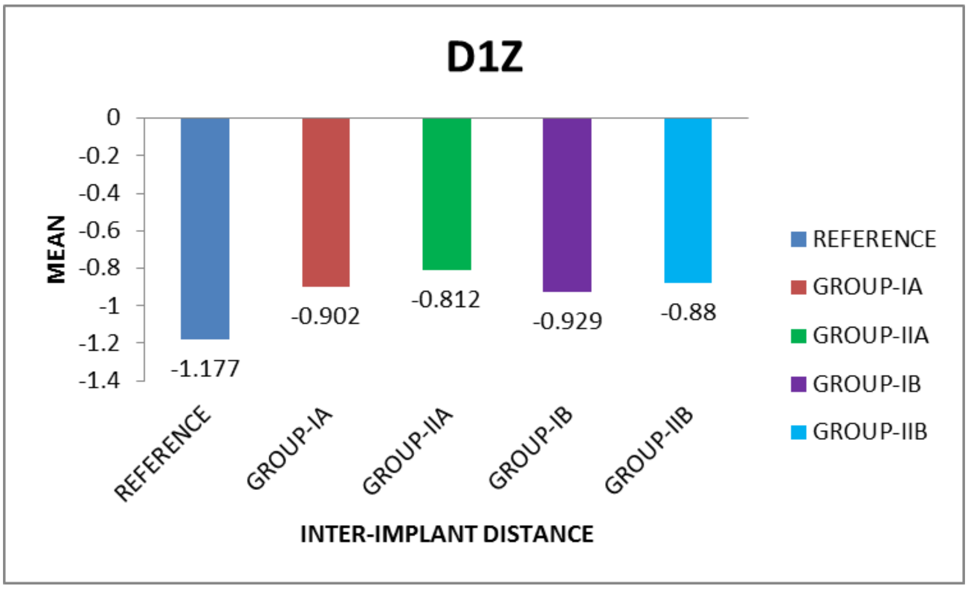
GRAPH: 8 COMPARISON OF INTER –IMPLANT DISTANCE IN D_3Y-AXIS



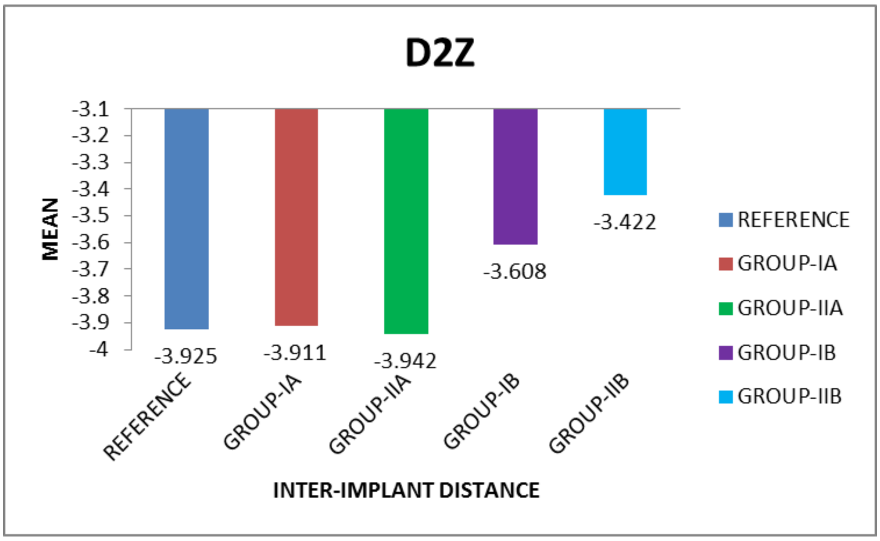
GRAPH: 9 COMPARISON OF INTER –IMPLANT DISTANCEIN Z-AXIS



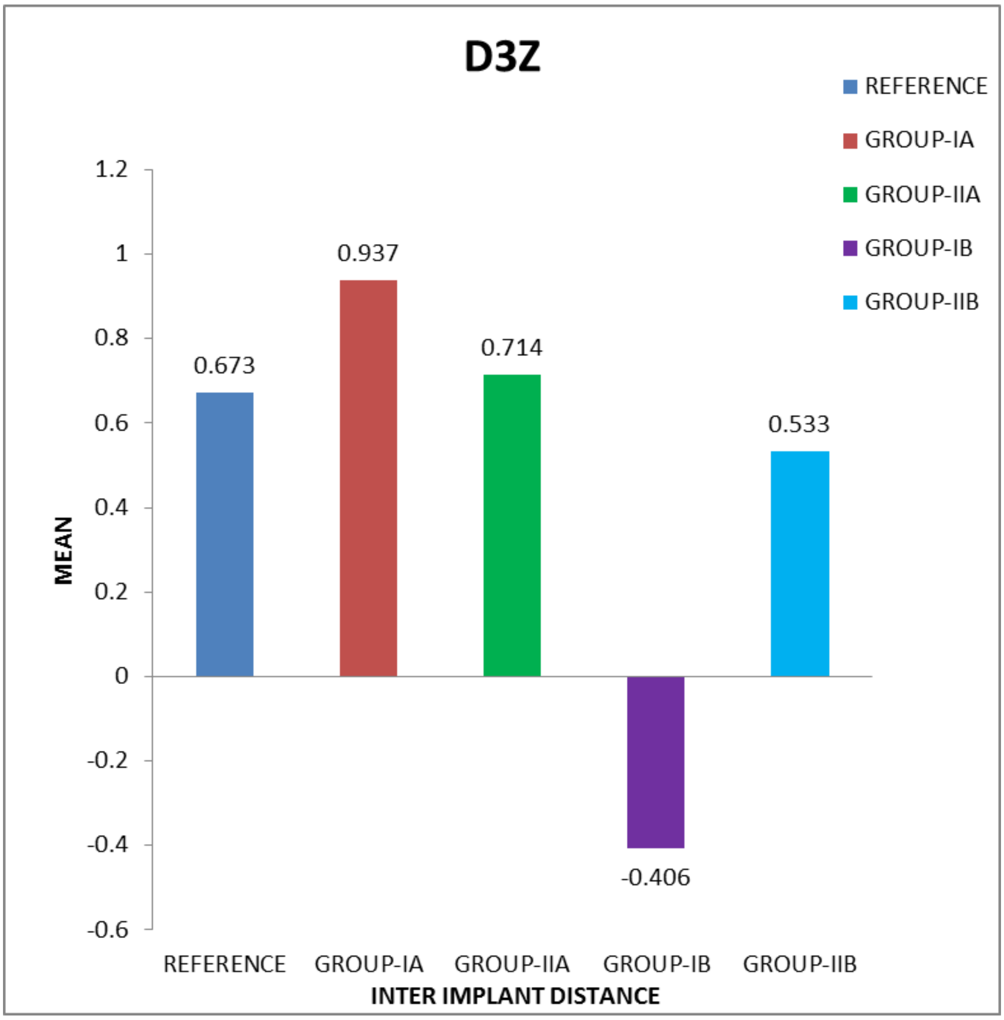
GRAPH: 10 COMPARISON OF INTER –IMPLANT DISTANCEIN D_1Z-AXIS



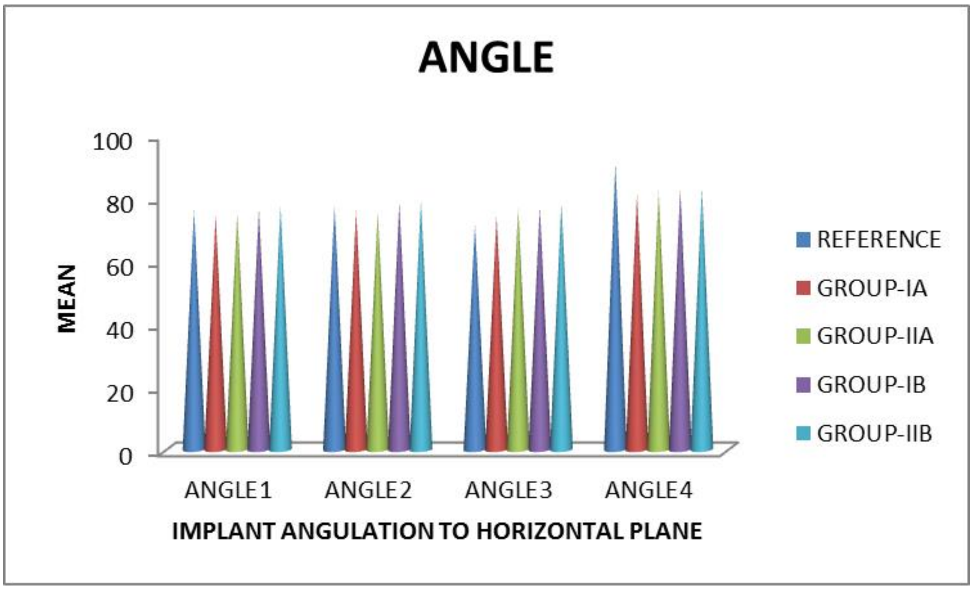
GRAPH: 11 COMPARISON OF INTER –IMPLANT DISTANCEIN D_2Z-AXIS



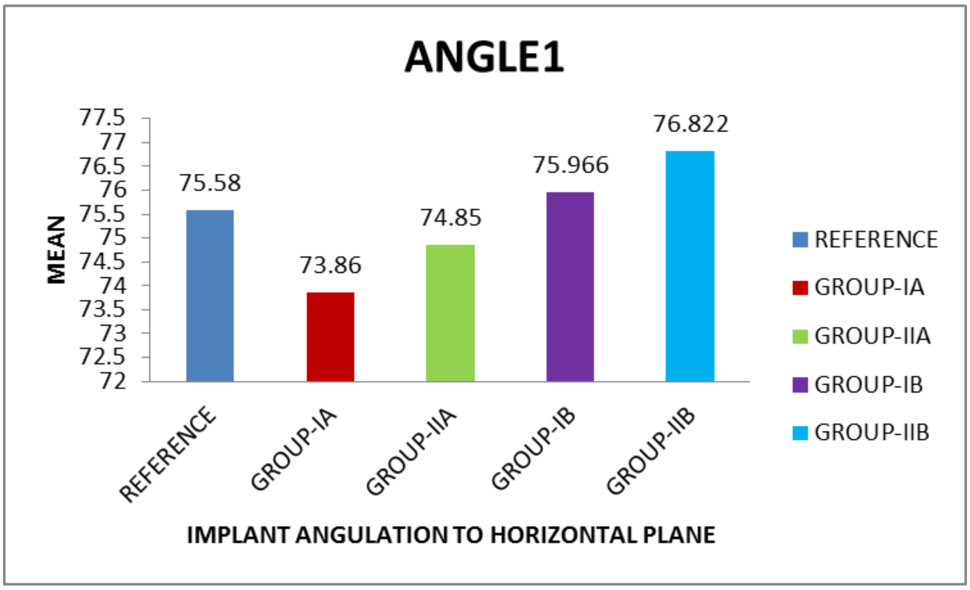
GRAPH: 12 COMPARISON OF INTER –IMPLANT DISTANCEIN D_3Z-AXIS



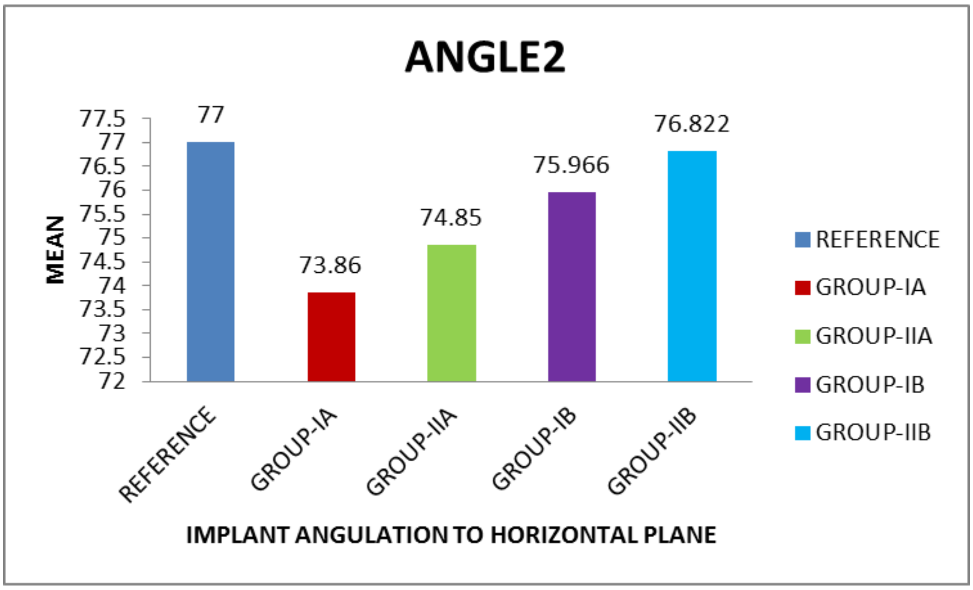
GRAPH: 13 COMPARISON OF IMPLANT ANGULATION TO HORIZONTAL PLANE IN Z-AXIS (Value in Degree)



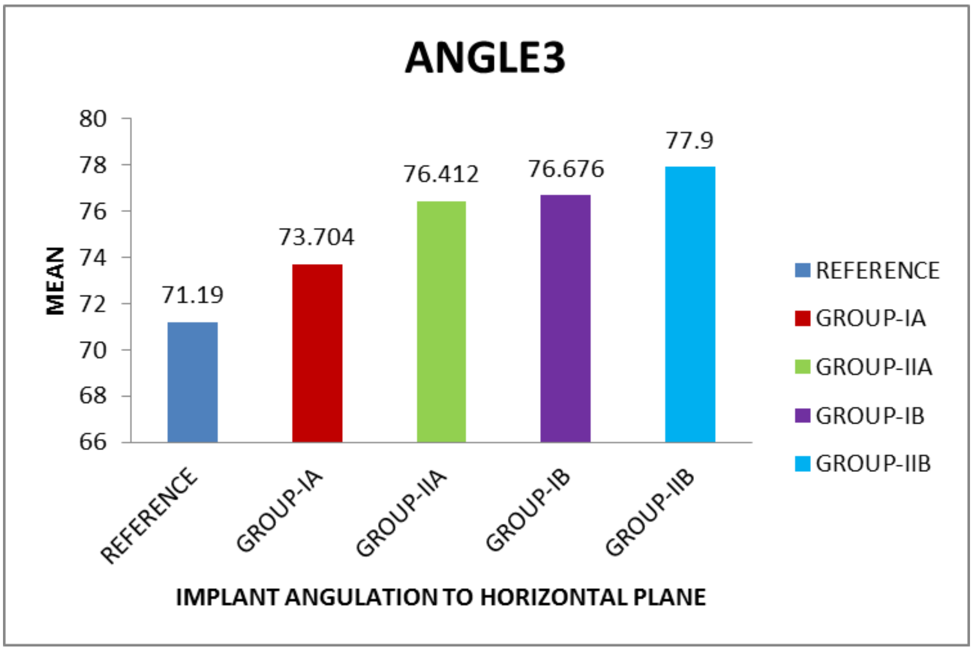
GRAPH: 14 COMPARISON OF IMPLANT ANGULATIONTO HORIZONTAL PLANE IN Z-AXIS ANGLE 1



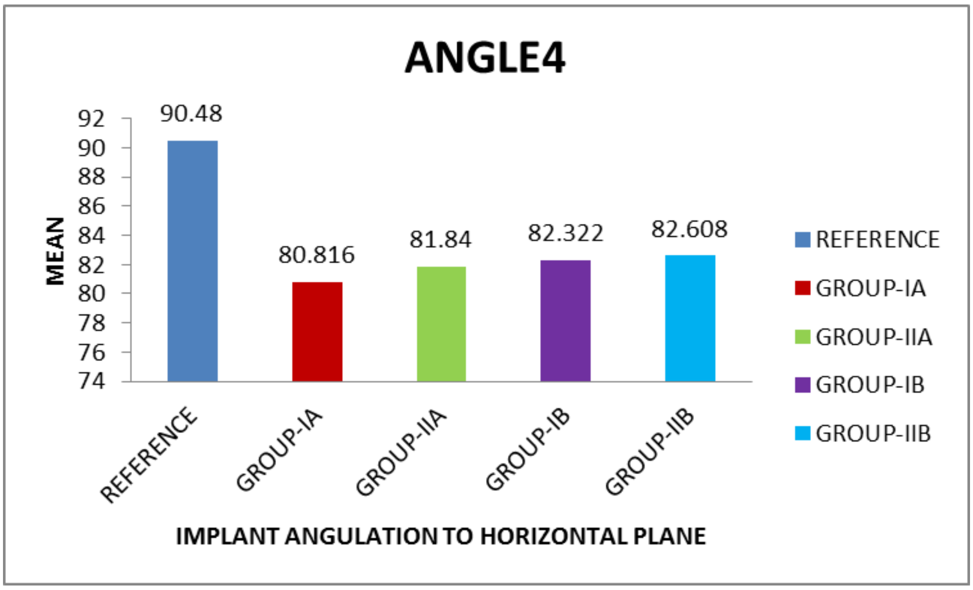
GRAPH: 15 COMPARISONOF IMPLANT ANGULATIONTO HORIZONTAL PLANE IN Z-AXIS ANGLE 2



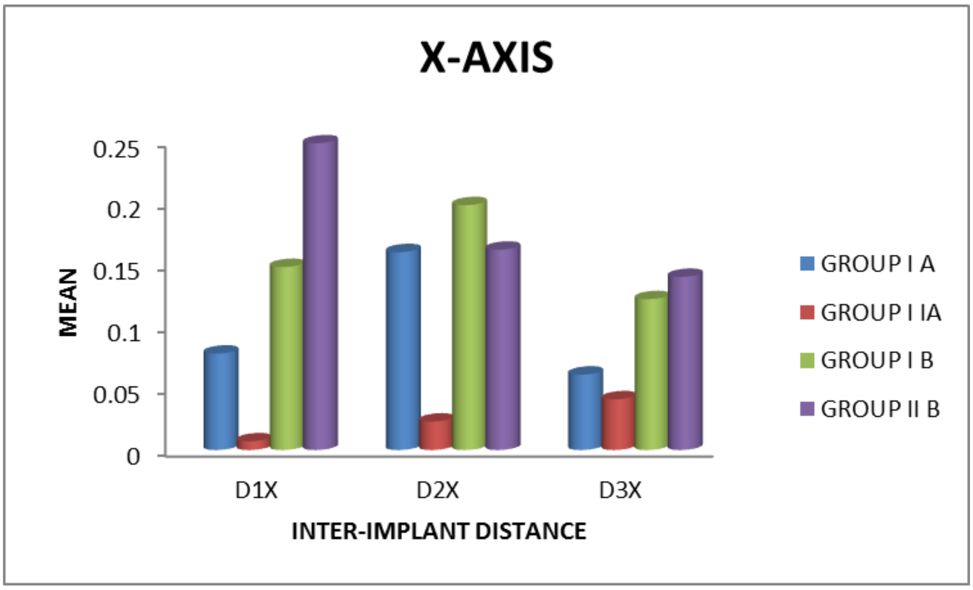
GRAPH: 16 COMPARISONOF IMPLANT ANGULATIONTO HORIZONTAL PLANE IN Z-AXIS ANGLE 3



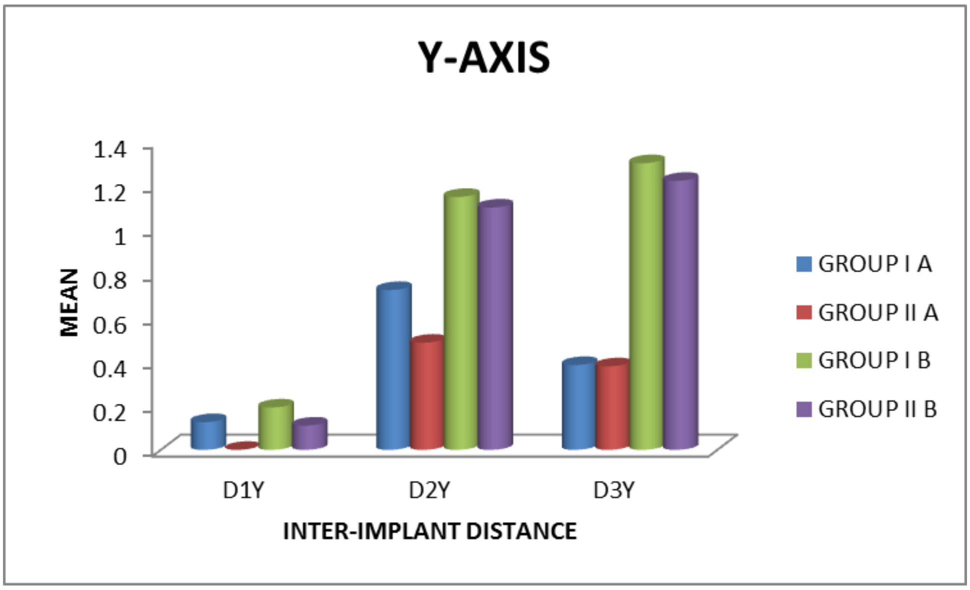
GRAPH: 17 COMPARISON OF IMPLANT ANGULATION TO HORIZONTAL PLANE IN Z-AXIS ANGLE 4



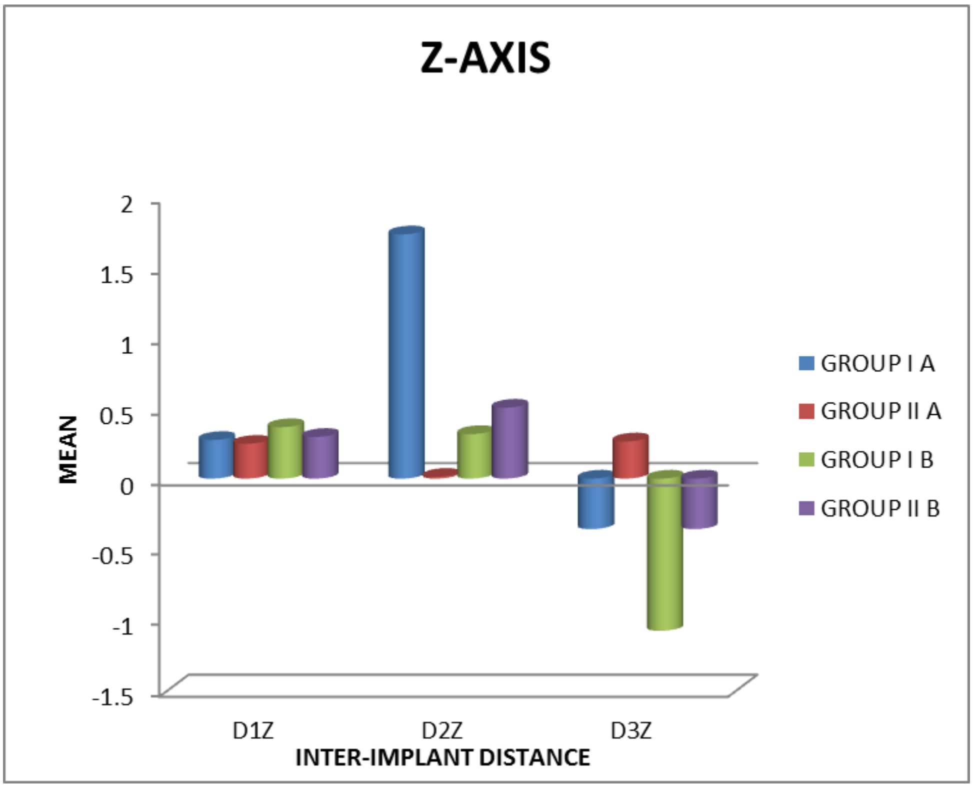
GRAPH: 18 DIFFERENCE IN INTER-IMPLANT DISTANCE IN X-AXIS



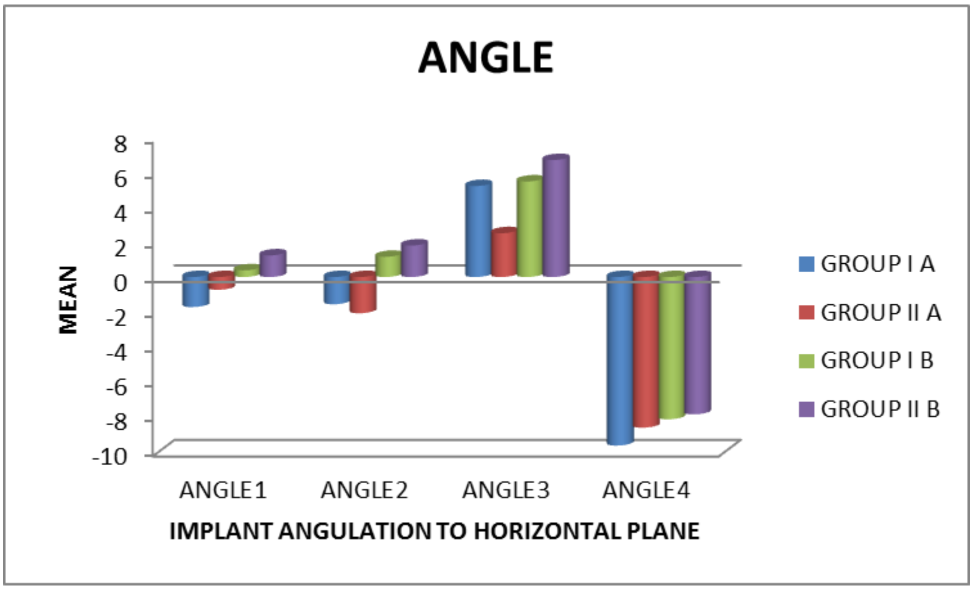
GRAPH: 19 DIFFERENCEIN INTER-IMPLANT DISTANCE IN Y-AXIS



GRAPH: 20 DIFFERENCEIN INTER-IMPLANT DISTANCE IN Z-AXIS



GRAPH: 21 DIFFERENCE IN IMPLANT ANGULATION TO HORIZONTAL PLANE IN Z-AXIS



Discussion

DISCUSSION

Osseointegrated dental implants have been proven successful in the treatment of edentulous patients. Mainly osseointegrated implants were used for rehabilitation of edentulous patient with the principal objective of replacing conventional complete denture with an implant supported prosthesis. In implant prosthodontics, a successful result can be achieved only when passively fitting prosthesis are fabricated. Reproducing the intraoral relationship of implants through impression procedure is the first step in achieving an accurate, passively fitting prosthesis[38].

Accurate transfer of implant position from the mouth to working cast, therefore remains a valid objective of relevance for the obtainment of optimum fit between the implant and superstructure. The preciseness of impression depends on two factors, the types of impression technique and impression materials used[17].

There are two basic implant impression techniques which have been used for transferring the impression copings from implants to the impression site such as open tray and closed tray technique[56]. Most of the authors have found that the open tray technique is more superior in accuracy than closed tray technique. In a study, Carr concluded that the open tray technique considered to besuperior[10,11]. Kwon et al suggested that the implant impression with open tray copings gave more accurate definitive casts, and precision of impression is more accurate in open tray than closed tray[37].

Among the direct impression technique both splinting and non-splinting have been advocated for accurate impression[19,46]. Rotation of impression copings in the impression during fastening of the implant analog was one of the main drawbacks of direct impression technique[19,55]. To avoid distortion of the impression coping, splinting of impression coping was advocated. The underlying principle is that all the impression copings were joined together using a rigid material so that movement of individual coping is avoided during the impression making procedure[37]. Kim et al showed that the splint technique was more accurate during the fabrication of cast than the nonsplinted technique[28].

Materials used to splint include light curing composite resin, impression plaster, thermoforming material, acrylic resin, autopolymerising acrylic resin[15].Although splinting with resin, has been recommended for maintaining inter-implant relationship, the accuracy of these technique is still controversial, in order to have rigid dimensionally stable material. Recently a newer material, BisGMA was used to splint the impression copings[46].

Most commonly used impression materials in implant dentistry are VPS and PE elastomeric impression materials. VPS are often used as they have excellent dimensional stability, superior deformation, elastic recovery and accurate reproduction of details[15].There are numerous studies, done to investigate the accuracy of impression materials for implant impression and it was found that PE and VPS provided superior reproduction in comparison of other impression material[28,58]. Lee et al reported that VPS impression material was more accurate than the PE impression material[57].

The most important property of an impression material is the wetability which helps provide detail reproduction in wet oral surfaces and also reproduces the details accurately with Gypsum slurry. As VPS is a hydrophobic material, manufacture have added extrinsic surfactants to improve its wettability both intraorally as well as with Gypsum slurry thus making it hydrophilized VPS[15].

A newer impression material VPES is a combination of VPS and PE has been introduced which according to the manufacturer, has intrinsic hydrophilicity and high dimensional stability. However the studies regarding the accuracy and reproductivity of VPES impression material for implant impression in comparison with other impression material are sparse[15,34].

In light of the above consideration, the aim of the in vitro study was to compare and evaluate the positional accuracy of implants with different splinting materials like pattern resin and BisGMA, using two different elastomeric impression materials like VPS and VPES.

An edentulous mandibular model with four implant replica in the anterior symphyseal region between the inter-mental foramina area was used as the reference model (control group) in this study. This was to resemble a clinical situation where in a minimum of four implants are required to give a fixed implant prosthesis.

A total of twenty custom trays with a spacer thickness of 2mm was fabricated on a spaced primary cast to ensure standardisation. This ensured that bulk of the impression material was the same in all the impressions made. Twenty custom trays with window in the anterior region were made using autopolymerising acrylic resin. Tray left undisturbed for 24hours prior to impression making to ensure dimensional stability and to minimize the polymerisation shrinkage. The samples were divided into four groups based on splinting technique and impression material usage. Group I (A): The pattern resin as splinting material with VPS impression material was used. Group II (A): The pattern resin as splinting material with VPES impression material was used. Group I (B): The BisGMA as splinting material with VPS impression material was used. Group II (B): The BisGMA as splinting material with VPES impression material was used.

Pattern resins with 2mm uniform thickness were used to standardise the same thickness in all the impressions using custom made mould. The study done by Burawiet et al reported that splinting done before 24hours of impression making showed lesser polymerisation shrinkage than splinting at the time of impression[8].

In this study pattern resin with 2mm thickness was made before 24hours using custom made mould it was sectioned and reunited at the time of impression making, using brush and bead technique, and it could have minimised the polymerisation shrinkage.

Sunanthaet al suggested a newer material BisGMA was used to splint the impression copings. Because of its advantages such as easy handling, less time consuming, less technique sensitive which is readily available[46]. Studies shown that, BisGMA had produced significantly positive result, while using as a splinting material. In this study BisGMA was used. Putty index was fabricated in pattern resin splinted control model, to maintain the standardized thickness of 2mm.

Nassar et al reported that VPS and VPES impression material showed excellent dimensional stability, but VPES showed more accuracy in immediate pouring of the casts, While VPS shows accuracy after one day storage of impression[34].In this study, both VPS and VPES impression materials were used.

A total of twenty casts were obtained from twenty impressions of which ten cast were obtained from VPS impression material, ten casts were from VPES impression materials. All the cast were measured using co-ordinate measuring machine. Dimensional change could occur in any direction, to study the magnitude of error occurring in three dimension, the inter implant distances, and angulation were measured in X, Y, Z axis using coordinate measuring machine.

Distortion can be measured as either absolute or relative. In absolute distortion analysis, an external reference point is used, while in relative distortion analysis, one implant/abutment is used as a reference for measuring distortion. Because the prosthesis connects all the implant together, the amount of strain on the implant is related to the relative position of the implants to one another. Therefore, absolute distortion analysis was done in this study by measuring the inter implant distance and angulation.

The difference in inter implant distance in X-axis ranged from0.0786(78.6μm) to 0.16(6μm)for groupI (A),and0.00720(7μm) to 0.1222 for group II (A), 0.198to 0.0410for group I (B), 0.2488 to 0.0140 for group II (B). The X-axis values (D_1X,D_2X,D_3X) have increased for group I (A), and decreased for group II (A), I(B), II(B). Casts obtained from pattern resin with VPES were very close to the reference model in X-axis, than those obtained from other groups. Spector et al reported an error upto 20-180μm in X axis and Lee et al reported an error up to 14±11.3μm in x-axis. Thus in comparison to the reference model, the difference in x-axis obtained in this study was within the similar range when compared with previous studies. There is no significant difference between test groups and reference model.

The difference in inter implant distance in Y-axis range from 0.1264to 0.7250 for group I (A),0.000 to 0.4862for group II (A), 0.1923to 1.300for group I(B), 0.1100 to 1.220 for group II (B). Group I (B) and Group II(B) showed especially an increase in inter implant in D_3Y than D_1Y,D_2Y whereas the group I(A) and II (A) showed the smallest increase in inter implant distance.Also the group II (A) shows nearest value to the reference model.

In the Z-axis, inter implant distance difference ranged from 0.274 (27µm) to 0.264 (26µm) for Group I (A), for Group II (A) 36µm to -35µm, for Group I (B) 24µm to -107µm, for Group II(B) 29µm to -139µm. D_2Z, value had been increased for all the groups, Group II(A),I(B),II(B) showed the minimum distortion, while Group I (A) showed maximum deviation. This Z-axis difference could be attributed to the rigidity of the splinting material that was used to prevent the movement of copings in the vertical direction, during the connection of the implant replica to the impression copings. Group II (A), I (B), II (B) shows negative results that shows minimum distortion. A Variability of 20µm caused by repeated screw fastening has been reported. Also a vertical gap of 50µm to 100µm has been published as acceptable; as it can be compensated by an extra half turn of the screw that connected the different implant component[19]. In this study, differences in the value were similar to the previous studies.

The difference in inter implant angulation in Z-axis ranged from -1.72 to -9.664 degree for Group I (A), -0.73 to -8.640 degrees for Group II(A), 0.3860 to -8.158 degrees for Group I(B), 1.242 to -7.872 degrees for Group II (B). There was statistically significant difference between Angle 2,3,4 of the test groups to the reference model.

With regard to the rotational distortion in the Z-axis, maximum difference were seen in Group II (B) 6.71 degrees, followed by Group I (B) 5.486 degrees, Group II (A) 2.514 degrees, Group I(A) 5.222 degrees. The angular difference could be the result of finger tightening of the implant replica to the impression coping. The negative values seen in the pattern resin splinted group reflected the rigidity of the resin in preventing the rotation of the impression copings.

Reports of tolerance between implant and abutment and the existence of rotational freedom of about 5.5 degrees between implant and abutment, suggests that the values obtained in this study were within clinically acceptable limits[19].

The minimum rotational discrepancy obtained in this study for Group II (A) also reinforce the need for a rigid impression material, Wee et al reported that the impression material for the direct implant impression technique require, rigidity to hold the impression copings, to prevent accidental displacement and minimal positional distortion between implant replicas[55].

For the direct impression technique, impression material should show sufficient rigidity to hold the coping in its position and prevent any displacement during the removal of the impression[15]. PE and VPS have been suggested as the material of choice for impression due to the superior chemical properties. Use of PE is recommended for fully edentulous and multi implant cases. Yilmaz et al suggested that the elastic recovery is a significant factor in determining the accuracy of an impression material[58]. The use of a more elastic material may reduce the permanent distortion caused by the stress between the copings and the implant impression material. Thus VPS could be considered as a feasible option especially when non parallel implants are present.

VPES is a commercially newer material, it is a combination of both VPS and PE and also it is a hydrophilic material that presumably maintains the stability of the material. Nassar et al reported that the VPES behaved more like polyether, and also reported that the VPES was the most accurate and dimensionally stable when it is immediately pour than it was stored for 2 days[34]. Regardless of the impression material and splinting materials no significant difference was detected between groups, but the pattern resin with VPES, showed minimum distortion value in comparison with the reference model, also it shows very nearest value to the reference model in all the three axis.

Assunaco et al stated that in a good impression, a discrepancy of 50µm may be found in any axis .The discrepancies are not only caused by the accuracy of impression technique and materials but also by the machining tolerance between the implant and the impression coping and abutments[4]. Ma et al reported machining tolerance between implant components ranging from 22µm to 100µm[27]. Hariharan et al reported that splinting might rigidly hold the impression copings together[19]. Lee et al, Dumbrigue et al, Naconey et al, suggested that pattern resin splinting before 24 hours and then reunited the material at the time of impression making[29].

Measurement made in all three axis in the present study showed that pattern resin splinting material with VPES impression material showed minimal distortion value in inter implant relationships in all axes. Although significant differences might not be present in individual axis measurements, the collective error occurring because of dimensional changes in all the axes might play a role in the passive fit of the prosthesis[19].

The results obtained in this study were in line with those obtained from the previous studies. Although there is no significant variation between the splinting materials and impression materials used in this study, but values obtained from splinting with pattern resin and VPES as impression material test group was very close to the reference model, thus in turn will improve the passivity of the final prosthesis. In this regard, pattern resin as splinting material which was made before 24 hours prior to the procedure, and VPES impression material has been advocated as reliable impression technique for the multiple implants.

The limitation of this study was the measurement of distances and the angulations between the replicas in the reference model. But framework was not fabricated on the reference model which would have helped to assess the passivity and impeccable fit of the framework over the study models. Also all impressions were made under ideal conditions without the presence of soft tissues, blood and saliva, which may affect the accuracy of the impressions[15]. Further studies can be conducted clinically to assess the amount of discrepancies that can occur in actual clinical situation.

Conclusion

CONCLUSION

The following conclusions were drawn within the limitations of this in vitro study, which compare and evaluate the positional accuracy of implants with two different splinting materials using two different elastomeric impression materials.

1) The mean inter implant distances in x axis for casts obtained from impressions using open tray impression copings with pattern resin splinting material and VPS impression material (Group I(A),) were **7.466mm, 23.664mm, 34.286mm** for D_1X, D_2X and D_3X respectively.
2) The mean inter implant distances in x axis for casts obtained from impressions using open tray impression copings with pattern resin splinting material and VPES impression material (Group II(A),) were **7.395mm, 23.525 mm, 34.239mm** forD_1X, D_2X and D_3X respectively.
3) The mean inter implant distances in x axis for casts obtained from impressions using open tray impression copings with BisGMA splinting material and VPS impression material (Group I(B)) were **7.536mm, 23.700mm, 34.266mm** for D_1X, D_2X and D_3X respectively.
4) The mean inter implant distances in x axis for casts obtained from impressions using open tray impression copings with BisGMA splinting material and VPES impression material (Group II(B)) were **7.636mm, 23.664mm, 34.347mm** for D_1X, D_2X and D_3X respectively.
5) The mean inter implant distances in y axis for casts obtained from impressions using open tray impression copings with pattern resin splinting material and VPS impression material (Group I(A)were **8.872 mm, 9.677 mm, 1.129mm** for D_1Y, D_2Y and D_3Y respectively.

6) The mean inter implant distances in y axis for casts obtained from impressions using open tray impression copings with pattern resin splinting material and VPES impression material (Group II(A)) were **8.746mm, 9.438mm, 1.050mm** for D_1Y, D_2Y and D_3Y respectively.

7) The mean inter implant distances in y axis for casts obtained from impressions using open tray impression copings with BisGMA splinting material and VPS impression material (Group I(B)) were, **8.938mm, 10.099mm, 2.050mm** for D_1Y, D_2Y and D_3Y respectively.

8) The mean inter implant distances in y axis for casts obtained from impressions using open tray impression copings with BisGMA splinting material and VPES impression material (Group II (B)) were, **8.856mm, 10.051mm, 1.970mm** for D_1Y, $D_2Y$and D_3Y respectively.

9) The mean inter implant distances in z axis for casts obtained from impressions using open tray impression copings with splinting material pattern resin and VPS impression material(Group I(A)) were **-0.902mm, -3.911 mm, 0.937mm** for D_1Z, D_2Z and D_3Z respectively.

10) The mean inter implant distances in z axis for casts obtained from impressions using open tray impression copings with pattern resin splinting material and VPES impression material (Group II(A)) were **, -0.812 mm, -3.942 mm, 0.714mm** for D_1Z, D_2Z and D_3Z respectively.

11) The mean inter implant distances in z axis for casts obtained from impressions using open tray impression copings with BisGMA splinting material and VPS impression material (Group I(B)) were **-0.929mm, -3.608mm, -0.406mm** for D_1Z, D_2Z and D_3Z respectively.

12) The mean inter implant distances in z axis for casts obtained from impressions using open tray impression copings with BisGMA splinting material and VPES impression material(Group II (B)) were**, -0.880mm, -3.422mm, 0.533mm** for D1Z, D2Z and D3Z respectively.

13) The mean implant angulation in angle for casts obtained from impressions using open tray impression copings with pattern resin splinting material and VPS impression material (Group I(A)) were **73.860 degree, 75.442 degree 73.704 degree, 80.816 degree** for angle 1, angle 2, angle 3 and angle 4 respectively.

14) The mean implant angulation in angle for casts obtained from impressions using open tray impression copings with pattern resin splinting material and VPES impression material(Group II(A)) were ,**74.850 degree, 74.926 degree, 76.412 degree, 81.840 degree** for angle 1, angle 2, angle 3 and angle 4 respectively.

15) The mean implant angulation in angle for casts obtained from impressions using open tray impression copings with BisGMA splinting material and VPS impression material (Group I(B)) were **75.966 degree, 78.160 degree, 76.676 degree, 82.322 degree** for angle 1, angle 2, angle 3 and angle 4 respectively.

16) The mean implant angulation in angle for casts obtained from impressions using open tray impression copings with BisGMA splinting material and VPES impression material (Group II(B)) were ,**76.822 degree, 78.806 degree, 77.900 degree, 82.608 degree** for angle 1, angle 2, angle 3 and angle 4 respectively.

17) On comparison with the reference model, casts obtained from impressions using pattern resin splinting material and VPS impression material (Group I(A)) exhibited differences in the inter implant distances in the range from **0.0786mm** to **0.1300mm** in x-axis.

18) On comparison with the reference model, cast obtained using from impressions pattern resin splinting material and VPES impression material (Group II(A)) exhibited differences in the inter implant distances in range from **0.0072mm** to **0.1222mm** in x-axis.

19) On comparison with the reference model, cast obtained from impression using BisGMA splinting material and VPS impression material (GroupI(B)) exhibited differences in the inter implant distances in range from **0.0410mm** to **0.198mm** in x-axis.

20) On comparison with the reference model, cast obtained from impression using BisGMA splinting material and VPES impression material (GroupII(B)) exhibited differences in the inter implant distances in range from **0.2488mm** to **0.0140mm** in x-axis.

21) On comparing the mean values between reference model and group I(A), group II(A),group I(B), group II (B),shows were not statistically significant difference was found in x-axis.

22) On comparison with the reference model, casts obtained from impressions using pattern resin splinting material and VPS impression material (GroupI (A)) exhibited differences in the inter implant distances in the range from **0.126mm** to **0.725mm** in y-axis.

23) On comparison with the reference model, cast obtained from impression using pattern resin splinting material and VPES impression material (GroupII(A))

exhibited differences in the inter implant distances in range from **0.000mm** to **0.4862mm** in y-axis.

24) On comparison with the reference model, cast obtained from impression using BisGMA splinting material and VPS impression material (GroupI(B)) exhibited differences in the inter implant distances in range from **0.192mm** to **1.300mm** in y-axis.

25) On comparison with the reference model, cast obtained from impression using BisGMA splinting material and VPES impression material (GroupII(B)) exhibited differences in the inter implant distances in range from **0.000mm** to **1.220mm** in y-axis.

26) On comparing the mean values between reference model and group I(A), groupII (A), group I(B), groupII(B), shows were not statistically significant difference was found in y-axis.

27) On comparison with the reference model, casts obtained from impressions using pattern resin splinting material and VPS impression material (GroupI(A)) exhibited differences in the inter implant distances in the range from **0.274mm** to **1.732mm** in z-axis.

28) On comparison with the reference model, cast obtained from impression using pattern resin splinting material and VPES impression material (GroupII(A)) exhibited differences in the inter implant distances in range from **0.013mm** to **0.264mm** in z-axis,

29) On comparison with the reference model, cast obtained from impression using BisGMA splinting material and VPS impression material (GroupI(B)) exhibited differences in the inter implant distances in range from **0.316mm** to **-1.079mm** in z-axis.

30) On comparison with the reference model, cast obtained from impression using BisGMA splinting material and VPES impression material (GroupII(B)) exhibited differences in the inter implant distances in range from **0.296mm** to **-0.139mm** in z-axis.

31) On comparing the mean values between reference model and group I(A), group II(A),group I(B), group II(B),D_2Z shows statistically significant difference was found in z-axis

32) On comparison with the reference model, cast obtained from impressions using pattern resin splinting material and VPS impression material (GroupI(A)) exhibited differences in the implant angulation to horizontal plane in the range from **-9.664 degree** to **5.222 degree** in angle.

33) On comparison with the reference model, cast obtained from impression using pattern resin splinting material and VPES impression material (GroupII(A)) exhibited differences in the implant angulation to horizontal plane in range from **-8.640 degree** to **2.514 degree** in angle.

34) On comparison with the reference model, cast obtained from impression using BisGMA splinting material and VPS impression material (GroupI(B)) exhibited differences in the implant angulation to horizontal plane in range from**-8.158 degree** to **5.486 degree** in angle.

35) On comparison with the reference model, cast obtained from impression using BisGMA splinting material and VPES impression material (GroupII(B)) exhibited differences in the implant angulation to horizontal plane in range from **-7.872 degree** to **6.710 degree** in angle.

36) On comparing the mean values between reference model and group I (A), group II(A), group I(B), group II(B), statistically significant difference was

found in angle 2, angle 3,angle 4 in group I(A), group II (A),group I(B), group II(B).

On comparison of positional accuracy of implants with two different splinting materials using two different elastomeric impression materials the GroupII(A) VPES Impression material with pattern resin splinting material>**GroupI(A)**VPS Impression material with pattern resin splinting material**>GroupII(B)**VPES Impression material with BisGMA splinting material**>GroupI(B)**VPS Impression material with BisGMA splinting material**.**

Summary

SUMMARY

This study was conducted to compare and evaluate the positional accuracy of implants with two different splinting materials using two different elastomeric impression materials. A reference model of the edentulous mandible with four implant replicas in the anterior region was fabricated in heat cure clear acrylic resin and was used as control group in this study (Control-Group R). The impression techniques were divided into two groups, pattern resin as splinting material using VPS and VPES as impression material and BisGMA as splinting material using VPS and VPES as impression material and grouped as Group I(A), II(A) and Group I(B), II(B) respectively. Five impressions of the reference models were made in each group with custom trays using VPS and VPES impression material. The impressions were poured using type IV dental stone and the retrieved master casts were grouped and evaluated for positional accuracy of inter implant relationship using a Coordinate measuring machine. Nine inter implant distances, three each in x, y and z axes and four implant angles in z axis were measured from the reference model and the master casts. The differences in the inter implant distances in x, y and z axes and the implant angular differences in the z-axis, in relation to the reference model were measured for all the casts. The results were tabulated and statistically analysed using one way ANOVA and Post-Hoc test.

The impressions made with open tray impression coping with pattern resin as splinting material and impression material VPS and pattern resin as splinting material with VPES impression material (Group I(A) and Group II(A)) Group II(A) showed minimum distortion values in inter implant distances in x, y and z axis and minimum angular differences axis in comparison with the reference model (Control-

Group R). The difference in distances and angulation does have statistical significance in D2Z and Angle 2, Angle 3, Angle 4.

The impressions made with open tray impression copings with Bis GMA splinting material with VPS and VPES impression material (Group I(B) and II(B)) showed differences in inter implant distances in x, y and z axis in comparison with the reference model (Control-Group R). The differences in distances do not have statistical significance. The angulations in z axis exhibited difference at one of the angles between replica2 replica3, replica4 as angle2, angle3, angle4which has statistical significance.

On comparative evaluation of master casts obtained from implant level impressions open tray splinted with pattern resin and BisGMA and VPS and VPES impression materials, the accuracy of these casts is comparable to the reference model. The results obtained in this study indicates that splinting with pattern resin and VPES impression material casts exhibited minimum distortion value in inter implant distances and angulations.

The following conclusions were arrived within the limitation of this in vitro study, cast obtained from Impression technique using pattern resin as splinting material with VPES impression material(Group II (A)) showed nearest value to the reference model within clinical limits when comparing with all other test groups.

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